Journal of the Association for Information Systems

JAIS

Research Article

Interrupting the Workplace: Examining Stressors in an Information Technology Context

Pamela S. Galluch
Roanoke College
galluch@roanoke.edu

Varun Grover
Clemson University
vgrover@clemson.edu

Jason Bennett Thatcher
Clemson University
jason.b.thatcher@gmail.com

Abstract

Contemporary information and communication technologies (ICTs) such as e-mail and instant messaging create frequent interruptions in the workday, which can potentially reduce business productivity and increase stress. However, we know little about how ICT-enabled interruptions cause stress and how individuals can use ICTs to cope with this stress. Using the transactional model of stress as the theoretical framework, we examines ICTs' influence on the stress process. We examine two demands that serve as stressors: quantity and content of ICT-enabled interruptions. These stressors influence perceptual stress, which then manifests into physical strain. To understand how to mitigate ICT-enabled stressors' influence, we examine three forms of control that potentially moderate demand's influence on the stress process: timing control, method control, and resource control. Timing control serves as a primary control, control that is present at the initial appraisal of an environment, while method control and resource control serve as coping behaviors, behaviors that individuals enact after they feel stressed. In order to rigorously assess the outcome variable, we used a non-invasive salivary technique to measure alpha-amylase, a hormone that is an objective indicator of strain. We used two laboratory experiments to test our model. In Experiment 1, we found that ICT-enabled demands served as stressors and led to perceptual stress and that ICT-enabled timing control negatively moderated the relationships between stressors and stress. In Experiment 2, we found that method control negatively moderated the relationship perceptual conflict had with strain, while increasing perceptual overload's relationship to strain. Resource control had the opposite finding: it negatively moderated perceptual overload's relationship with strain, while increasing perceptual conflict relationship with strain. The results provide insight into how ICTs create episodic stress and facilitate our ability to manage it. We conclude the paper with implications for research, methods, and practice.

***Keywords**: Technostress, Information and Communication Technology, Alpha-Amylase, Stressors, Strain, Transactional Stress, Demands Control Model, Interruptions*

* Fiona Fui-Hoon Nah was the accepting senior editor. This article was submitted on 26th November 2011 and went through two revisions.

Volume 16, Issue 1, pp. 1-47, January 2015

Interrupting the Workplace: Examining Stressors in an Information Technology Context

1. Introduction

Information and communication technologies (ICTs), such as email and instant messenger, are ubiquitous in organizational life; therefore, understanding their positive and negative effects is important. On the one hand, adopting these new ICTs enables individuals to share information and accomplish tasks more effectively. On the other hand, ICTs often introduce frequent interruptions into individuals' workdays that can increase stress and lower productivity.

ICT-enabled interruptions directly and indirectly affect productivity. For example, recent estimates suggest that ICT-enabled interruptions cost U.S. firms $650 billion per year in lost productivity (Spira & Feintuch, 2005). This figure is estimated based on the time workers spend in their inbox or tending to instant messages. Alongside direct costs, indirect costs of ICT-enabled interruptions are less understood. Estimates suggest that workers need approximately four minutes to reorient themselves to an original work task after an email interruption (Kessler, 2007). Other estimates suggest that, following an interruption, 40 percent of workers fail to return to their original task (Thompson, 2005). Overall, ICT-enabled interruptions may negatively affect individual productivity and so decrease organizational productivity.

In addition to lost time, ICT-enabled interruptions may also lead to technostress, or stress that directly or indirectly results from ICTs (Tu, Wang, & Shu, 2005; Weil & Rosen, 1997). Technostress from ICT-enabled interruptions produce short-term, episodic stress. Collectively, short-term episodes of technostress can lead to further problems down the road (i.e., role stress, loss of productivity, turnover intentions, etc.). If such stressors are not controlled, technostress can have an even greater impact on an organization's bottom line. Therefore, by limiting episodic stressors in the workplace, one can have a longer-term impact on the organization.

Little research has been conducted on technostress in the information systems (IS) field. The few examples of IS work focus technostress models on general stress perceptions (i.e., role stress, grounded in the organizational behavior literature) and link them to chronic outcomes (i.e., job satisfaction) (Ragu-Nathan, Tarafdar, & Ragu-Nathan, 2008). There has been no IS work on short-term, or episodic stress, which is a prominent feature of today's ICT environment and can have a dramatic impact on the workforce's productivity.

Within the transactional perspective on stress (Cooper, Dewe, & O'Driscoll, 2001), episodic stress refers to a short period of time in which a person feels stress and then is strained. Stress does not affect each person equally, but, collectively, all stress leads to further problems in the future (i.e., dissatisfaction and turnover). The transactional perspective considers people's perception of stress prior to measuring the reaction on their body (Lazarus & Cohen, 1977). In this paper, we argue that the characteristics of ICT-enabled interruptions themselves can be stressors that influence perceptions of stress, which, in turn, directly influence strain. However, we also seek to evaluate control, where forms of control (primary and coping mechanisms) can ameliorate that stress. Hence, to build a deeper understanding of how ICT factors relate to individuals' episodic stress, this study investigates how attributes of ICTs, the individual, and the interruption interact in a transactional perspective to produce stress in the workplace. We presume that high levels of episodic stress are undesirable for individual productivity and need to be managed by organizations through enabling forms of control (Dollard, Winefield, Winefield, & de Jonge, 2000). Hence, we investigate the following research questions:

- Do ICT-enabled forms of interruptions create demands that lead to episodic stress?
- If so, do ICT-enabled forms of control mitigate the effects of ICT-enabled interruptions on episodic stress?

The paper proceeds as follows. In Section 2 we ground our research in the transactional stress perspective. In Section 3, we develop a model of ICT-enabled interruptions. Then, in Section 4, we test our hypotheses through two experiments that manipulate features of the ICT and the context to evaluate the stressor-strain relationship. Finally, in Section 5, we discuss our findings, implications for research, methods, and practice, limitations of our study, and potential avenues for future research.

2. The Transactional Stress Perspective

Rooted in Selye's (1956) seminal work on stress, the transactional perspective suggests that stress is not a factor of the individual nor the environment, but rather an embedded ongoing process that involves individuals transacting with their environment, making judgments, and coping with issues that arise (Cooper et al., 2001). The transactional stress perspective considers frequency, severity, and duration of the stressful conditions (stressors) and the availability of stress-reducing resources (e.g., social support (Smith, 2006)). In this perspective, each stressor is understood in the context of the stress process. This perspective also puts more attention on the effects of coping, which, in the short-run, can immediately lessen the mind and body's view of strain, and, in the long-term, can cause people to "toughen" and adapt (Aldwin, 2007). Figure 1 depicts the transactional perspective of an ICT-enabled stress process and Table 1 defines its components.

Table 1. Definitions of the Components in the Transactional Perspective of Stress

Key stress term	Definition
Stress	The overall transactional process
ICT-enabled demand stressors	The objective demands that are enabled by ICTs and stress individuals (e.g., a high number of interrupting messages on a screen)
ICT-enabled primary control	The initial level of control over the ICTs (e.g., ability to control when the messages are received)
Primary appraisal	An individual's appraisal of the motivational relevance of the stressors
Perceived stress	The feelings of overload and conflict towards the demands and the forms of control in an environment
Secondary appraisal	An individual's belief of whether a change in ongoing conditions is perceived to be undesirable or desirable
Coping behaviors	Behaviors enacted to attempt to alter, change, or escape from the stressors (e.g., walking away or doing something else)
Strain	The psychological and physiological responses made by individuals based on the fit between perceived stress and coping behaviors (e.g., rapid heart-rate)

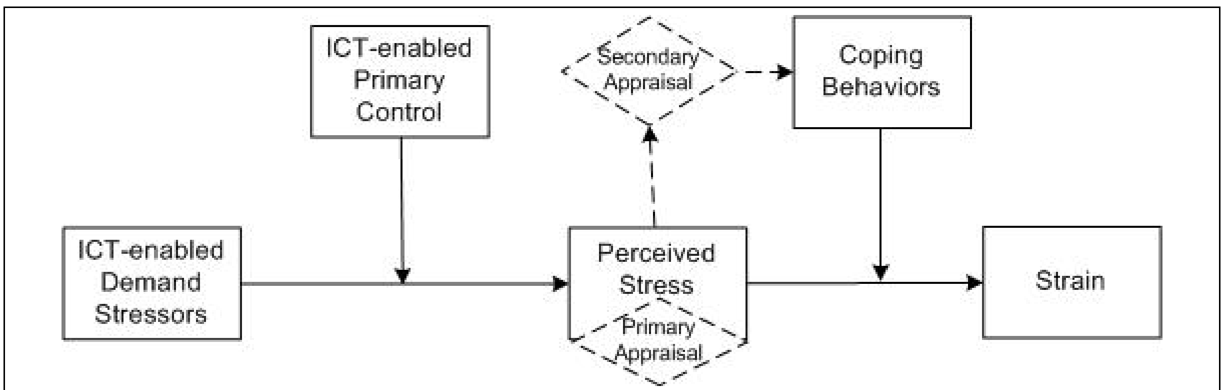


Figure 1. Transactional Model of Stress

There are many models that draw on the transactional perspective of stress. In this study, we focus on the person-environment (PE) fit model, which suggests that stress results from high demands or insufficient supplies to meet the person's needs (Ayyagari, Grover, & Purvis, 2011; Cooper et al., 2001; Edwards, 1996). We examine the PE fit model in the transactional perspective of stress for two reasons. First, one cannot ignore individual differences in perceiving and appraising stress. Second, stress results from either a mismatch of one or both of two dimensions of a person with one or both of two dimensions of the environment: between a person's abilities and the high demands placed on them or between a person's values and insufficient supplies to meet the person's needs (Ayyagari, 2007; Cooper, 1998; Edwards, 1996; French, Caplan, & van Harrison, 1982). Basically, this model accounts for personal characteristics, coping/control mechanisms, and characteristics about environmental demands.

We define stress as the overall transactional process (Cooper et al., 2001). In the PE fit model, a person's and environment's characteristics influence appraisal, which then determine coping responses. In our model, demand encompasses the environmental variables. It refers to the amount and type of demands and the perceived workload (Mullarkey et al., 1997) or overload (Kirmeyer & Dougherty, 1988) that results from that demand. We define ICT-enabled demand stressors as the objective demands that are enabled by ICTs and that stress individuals. For example, a high number of interruptions that are off-task can serve as demand stressors. Pressures of perceived workload or overload arise from the need to overcome demand, which creates stress (McGrath, 1976). Specifically, when workload is high, demands may exceed individuals' capabilities, which leads to feelings of overload (Kushnir & Melammed, 1991; Van Der Doef & Maes, 1999).

Personal control refers to individuals' ability to determine a variety of behavioral elements, such as method of working, the pace of work, and the work goals (de Jonge, Bosma, Peter, & Siegrist, 2000; Perrewe, 1987). ICT-enabled control is the initial level of control over the ICTs present in the initial environment (e.g., ability to control when the messages are received). We argue that technology enables varying levels of control and, therefore, provides solutions for accelerating demand. For example, emails that pop-up unexpectedly provide less control to individuals than software clients in which individuals choose when to check their email. In this example, control over timing through email clients helps mitigate the stress from high demand by allowing users to organize their workload without unintentional interruptions.

Transactional stress arises from primary and secondary appraisal processes (Lazarus, 1994). The primary appraisal is the motivational relevance of the encounter with the stressor. For instance, typically, individuals encounter ICT-enabled interruptions (a stressor) that may show up on their computer screen with certain regularity. Lazarus (1994) posited three primary evaluations at the onset of the stressor. First, is the stressor irrelevant and can it be ignored? Second, is the stressor benign but positive? Third, is the stressor harmful or threatening? If the stressor is appraised as harmful or threatening, the individual will perceive stress and engage in secondary appraisals in the stress process (Perrewe & Zellars, 1999).

The secondary appraisal assesses the probability that a coping behavior will accomplish the desired outcome (i.e., to reduce strain), whether the individual has the capability to perform the associated coping behavior, and the consequences of the coping behavior (Cohen, 1984; Lazarus & Folkman, 1984; Perrewe et al., 1999). Secondary appraisals span the evaluation period of actions prior to enacting a behavior. If the individual did not feel stressed during the primary appraisal, the individual would conclude that coping was not necessary in the secondary appraisal, and thus not take action (e.g., cope). Coping "deals with the adaptational acts that an individual performs in response to disruptive events that occur in his/her environment" (Beaudry & Pinsonneault, 2005, pp. 494). For instance, in an ICT-enabled context, individuals can cope with ICT-enabled interruptions by removing themselves from the stressors (resource control) or by changing the way they are using the technology (method control).

In conclusion, the transactional perspective forms the theoretical underpinning of our study. The transactional perspective allows us to categorize control as primary or secondary (i.e., coping behavior). In this perspective, the PE fit model helps us understand the fit between a person and an environment, while receiving stressors given a certain level of supplies. In Section 2.1, we connect ICT-enabled interruptions to this model by firstly defining an interruption, secondly discussing how interruptions occur at the episodic level of stress, and finally describing characteristics of interruptions that can be examined in light of our theoretical model.

2.1. Stressors: Episodic and Chronic

There are two general categories of stressors: chronic and episodic. A chronic stressor is a long-term, consistent, or reoccurring pressure in one's life (Beehr, Walsh, & Taber, 2000). Most of the literature has focused on chronic stressors to understand how they manifest long-term strain and decrease productivity. Chronic stress studies examine stressors such as work/family conflict, which refers to conflict where work roles and family roles are incompatible (Hammer, Kossek, Zimmerman, & Daniels, 2007). Providing solutions for this group of stressors would imply altering one's life to attempt to fix the problem and then gauging whether the change has permanently removed the issue. Researchers have also studied short-term or episodic stressors. An episodic stressor is a transitory negative event that occurs periodically but is not ongoing (Cooper et al., 2001). These stressors are categorized as acute or short-term stressors, and are labeled as episodic because they are inconsistent (i.e., sporadic) pressures in one's life (Beehr, Jex, Stacy, & Murray, 2000). Consequently, researchers do not use a set time limit to characterize all episodes because the duration can change according to how each episode is defined (e.g., being stuck in a traffic jam).

Episodic stressors can cause distress or eustress. Distress arises from negative reactions, and is the key factor in influencing illness. Eustress is positive stress, including facets like exercise, increased excitement, and learning. Eustress is related to sought-after encounters in a person's life, but can be just as easily taxing on the body if not controlled (Lazarus, 1993). For example, while short periods of increased physical arousal through exercise are good, prolonged continuous exercise can also lead to negative results (i.e., increased fatigue and stress on the body). We control for eustress in the paper and focus our efforts on understanding distress.

By limiting episodic stressors' impact in the workplace, one can mitigate both episodic and chronic stress. This is because episodic stressors have been shown to be the key factor in evaluating chronic stress, where chronic stressors were only found to be related to stress when paired with episodic stressors (Marin, Martin, Blackwell, Stetler, & Miller, 2007). For example, even though episodic stressors are short term, they have implications for the broader workplace in the long term: individuals who experience stress on a day-to-day basis are more likely to perform poorly and change jobs (Wright & Bonnett, 2007). Therefore, besides the costs from poor productivity, turnover costs (an outcome of chronic stress) increase because they require businesses to continually administer interviews, background checks, training, new-hire orientation, and physical examinations. This suggests that short-term stressors can cause short-term outcomes, such as loss of productivity, but can also feed into long-term outcomes, such as turnover. In order to address stress at the episodic level, the individual needs to gain an understanding of the stressors present and actively control for this irregularity.

In framing our model of technostress, we focus on episodic stressors as reflected in ICT-enabled interruptions. This allows us to frame an interruption-based study around the ICT-enabled pressures that surround an individual in the organization and that collectively lead to technostress.

2.1.1. ICT-enabled Interruptions at the Episodic Level

An interruption refers to any distraction that shifts individuals' attention away from a current task and requires conscious effort to return to the original task (Damrad-Frye & Laird, 1989). We focus on external interruptions as opposed to internal interruptions (e.g., mind wandering) because external interruptions are the only types of interruptions directly attributable to ICTs. External interruptions have been examined as intrusions, distractions, discrepancies, or breaks in individuals' attention (Jett & George, 2003). An intrusion is an unexpected encounter initiated by a person that interrupts the flow and continuity of an individual's work and brings that work to a temporary halt. This suggests that there must be flow or continuity (Tellegen & Atkingon, 1974) before an intrusion can occur. Distractions are psychological reactions triggered by external stimuli or secondary activities requiring additional cognitive processing that interrupt focused concentration on a primary task. Again, focused concentration must be established before a distraction can occur. Discrepancies are perceived inconsistencies between one's knowledge, expectations, and observations that are perceived to be relevant to the individual (Okhuysen, 2001). Breaks are planned or spontaneous recesses from work on a task that interrupt the task's continuity. Like interruptions in work practices, our conceptualization of interruptions possesses characteristics of intrusiveness, distractibility, and discrepancy. Breaks are distinct from this grouping because they result from the individual's decision to be interrupted—instead of imposed on the individual. Therefore, we can categorize ICT-enabled interruptions as intrusive interruptions, which may distract individuals' concentration, and may postpone the completion of their current goals.

ICT-enabled interruptions are different from non-ICT-enabled (i.e., traditional) interruptions in four main ways: 1) through a lack of social presence, 2) through distressing the already-limited technical workspace, 3) through the expectation of technology to be always on, and 4) through the ability to control the technology. First, ICT-enabled interruptions have less social presence than traditional interruptions. Social presence is the communicator's sense of awareness of the interacting partner (Gefen & Straub, 2004; Sproull & Kiesler, 1986). In the case of ICT, the cause of the disturbance need not be physically available to the interacting party. Correspondingly, contextual cues available through ICTs may not be as rich as those received in a traditional environment. Without rich contextual cues, ICT interruptions can be particularly jarring and manifest into negative outcomes such as increased conflict with the individual's current workload (Chun, 2000). Additionally, new technological devices may allow additional cues to come through the medium that may not be intended. For instance, while smartphones can make double-checking for grammar and correctness of content more difficult. This could send negative cues regarding “a lack of caring” that were never intended. Given that people tend to exhibit more uninhibited behavior through ICT (Sproull & Kiesler, 1986) and also have a greater ease of reaching multiple individuals (Courtney, 2007), ICT-enabled interruptions with their limited social presence can create greater disruptive issues than those in a traditional environment.

Second, ICT-enabled interruptions arise on a technical workspace (e.g., computer screen). Technical workspaces are small, which limits the space available for ICT-enabled interruptions to occur alongside technical tasks. This is different from traditional oral interruptions, which do not necessarily interrupt an individual's direct workspace. Instead, ICT-enabled interruptions influence individuals through an already-limited workplace, which directly intrudes on individuals' current ICT tasks.

Third, we live in an always-on culture, in which it is increasingly common not to turn off ICT devices, even when we are asleep (Perlow, 2012). While some jobs do not require much physical social interactions, we argue that these workers are still at risk to be distracted by ICT-enabled interruptions. Many workers may try to make time to close their door, or sit by themselves and work when an item is important to their job. However, because of our culture, these workers would still have a difficult time tuning out all the interruptions from ICTs. For example, if a boss emailed an employee, it is common to have expectations in place that would require a timely response. Turning off interruptions would then go against work expectations. Also, even if companies have blocking mechanisms in place for various websites, it is still easy for people to be overloaded with notifications on their smartphones. We believe it is highly difficult for people to prioritize a high number of ICT-enabled interruptions. Due to their potentially unique characteristics, we conclude that ICT-enabled interruptions are distinct from traditional interruptions because of their timing, frequency, cues, finite intrusion space, and culture surrounding them.

Finally, the affordances of technology allow for timing control and method control that are not available in the traditional work environment. For instance, Microsoft Outlook comes with options for organizing, codifying, and tracking emails of varying importance. Other programs provide options to change how we work on tasks. From a design perspective, this flexibility built into the systems is beneficial for reducing stress and is not possible with non-ICT mechanisms.

2.1.2. Transaction Perspective of Interruptions and Stress

The transactional perspective of stress suggests that person variables interact with environment variables through a cognitive process termed primary appraisal. If the environment is appraised as taxing, people cope. Our transactional model integrates insights from the transactional stress perspective and focuses on ICT-enabled (external) interruptions that have the capability to communicate a message. These interruptions are episodic stressors that create demands on the individual causing perceptual stress (primary appraisal), which, in turn, might be mitigated via using control (secondary appraisal) in the transactional process.

During the primary appraisal, perceptual stress is the key construct. This is the middle box in Figure 1. We focus on two forms of perceptual stress: overload and conflict (Parasuraman, Greenhaus, & Granrose, 1992). These distinct aspects of perceptual stress are widely used (Carlson, 1999; Peterson et al., 1995; Pierce, Gardmer, Dunham, & Cummings, 1993) and readily adapted to the episodic level. For instance, in his seminal work, Sales argued that role overload "was a condition in which the individual is faced with a set of obligations which, taken as a set, requires him to do more than he is able in the time available" (Sales, 1969, p. 325). This view conceptualizes each demand as separate that collectively led to changes in serum cholesterol. Therefore, while we can test changes at the chronic level, we can also test for short-term changes that will greatly influence long-term stress.

We contend that different stressors are formed from the variety of the interruptions' characteristics, which place demands on the individual and cause perceptual stress. First, ICTs can interrupt an individual during an episode in which the individual is completing a task, which creates extra workload requirements (Speier, Valacich, & Vessey, 1999). This stressor is known as quantitative demand, which increases with the number of ICT-enabled interruptions. We contend that ICT-enabled interruptions may create further demand by increasing the quantity of an individual's demand. Second, a message's profile can also serve as a stressor by creating demand in an ICT environment. For example, communication theory suggests that ICT-enabled interruptions can be profiled as instrumentally supportive or unsupportive of the task being done (Smith-Lovin & Brody, 1989). Therefore, an episode could have many interruptions, which each include messages that enable one to better complete a task. Such messages of support during a task minimize their negative effects towards stress. Finally, perceptual overload and perceptual conflict are situational dimensions that serve as proxies for stress (Carlson & Perrewé, 1999) and can be unequally influenced by the stressors (Nygaard & Dahlstrom, 2002).

In the transactional stress perspective, control can attenuate demand stressors through either primary or secondary appraisals, in which the initial level of control is determined from the primary appraisal that leads to stress, and coping behaviors are determined from the combination of the secondary appraisal with the initial level of stress to effect strain (Lazarus & Folkman, 1984). During the primary appraisal process, forms of primary control can ameliorate the stress created by interruptions. For example, the ability to control the timing of the interruptions (e.g., timing control) can enable primary control alongside the ICT-enabled interruptions. This suggests that primary control occurs alongside the assessment of the demand stressors and, therefore, can counteract perceptual stress before the individual feels strain.

After the individual feels stress, the individual conducts a secondary appraisal of the environment in order to search for ways to cope. Once coping behaviors are determined, they can be enacted during secondary appraisal before the individual is strained. We use method control and resource control as two distinct coping behaviors. We believe that method control allows individuals to exhibit control over the methods used in finishing their primary task by specifically allowing them to access methods that will help them accomplish their task. Resource control allows the individual to break from the stressful environment. These coping behaviors are only enacted when users feel stress from high interruption-based demands.

In sum, timing control is primary, while resource and method control are secondary. Both timing and method controls are ICT enabled, while resource control is a general form of coping that removes the individual from the technological environment when stress from demand requirements is high.

3. Hypotheses Development

Our research model is consistent with a transactional perspective on stress. Figure 2 presents the research model and Table 2 presents construct definitions. The model represents stressors created by ICT-enabled interruptions as two variables: quantity of interruptions and message profile. These variables increase overall demand. We argue that, by enabling timing control, ICTs limit the relationship ICT-enabled demands have with perceptual stress. We define perceptual stress as perceptions of stress, which have typically been operationalized as stressors when dealing with chronic roles in IS research (i.e., ambiguity and overload). In our study, these feelings of stress, termed stressors in previous studies, increase post-episodic objective stressors present in the environment. Therefore, our model focuses on objective stressors that lead to perceptions of episodic stress that finally create strain. Figure 1 operationalizes perceptual stress through episodic stressors as opposed to role stressors by tying them to specific ICT-enabled episodic stressors. Finally, we evaluate an ICT-enabled coping behavior, method control, and a general coping behavior, resource control, which overcomes the influence perceptual stress has on strain.

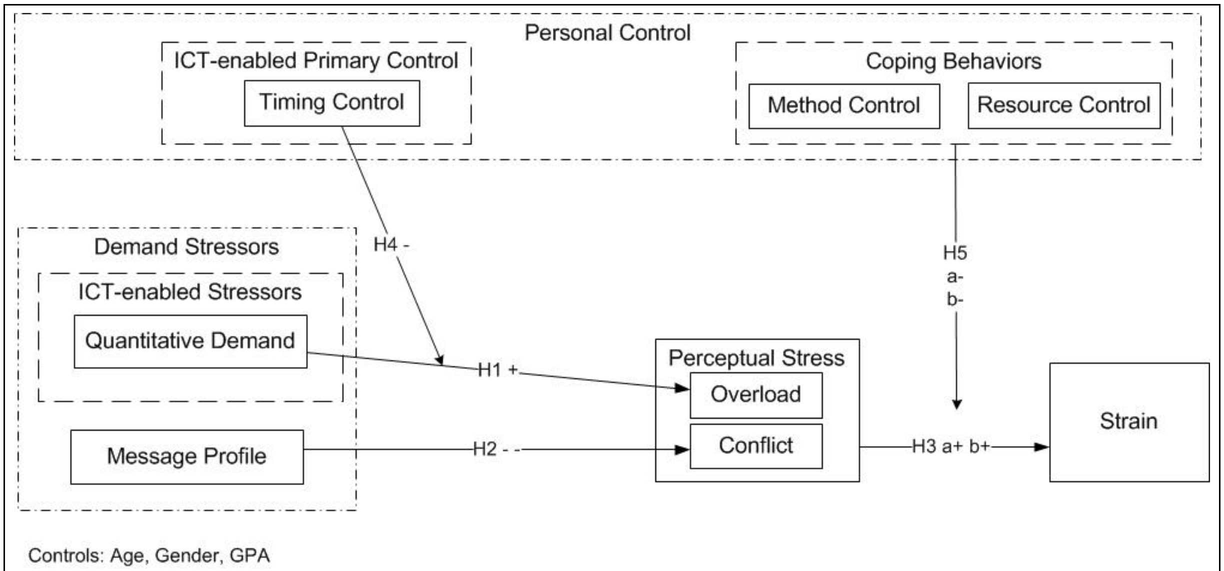


Figure 2. Formal Research Model

Table 2. Construct Definitions

Construct	Theoretical definition	Context specific definitions	Key references
Strain	The psychological and physiological responses of individuals to environmental demands.	The psychological and physiological responses of individuals to ICT-enabled demands.	Pearlin, Lieberman, Menaghan, & Mullan (1981), Perrewe (1987), Perrewe & Ganster (1989), Selye (1956), Selye (1983), Selye (1993)
Perceptual Stress	Characteristics of an organizational role in which the individual perceives adverse consequences. Overload: perceiving too much work to do in the given time period. Conflict: perceptions of incompatibility in the requirements of the role, where incompatibility is judged relative to a set of conditions that impinge upon performance.	Characteristics of an ICT-enabled episode in which the individual perceives adverse consequences from the interruptions or the messages. Overload: perceiving too many ICT-enabled interruptions in the given time period. Conflict: perceiving an incompatibility in the demand requirements, where the content of the message conflicts with the task.	Beehr et al. (1976), Kahn (1964), Karasek (1979), Perrewe (1987), Perrewe & Ganster (1989), Rizzo, House, & Lirtzman (1970), Toffier (1981)
Quantitative Demand	The quantity of demand.	The number of ICT-enabled interruptions.	Kushnir & Melamed (1991), Maslach, Schaufeli, & Leiter (2001)
Message Profile	Available aid from a relationship or network of relationships and the source of the instrumental (on-task/off-task) pressure.	The type of instrumental support tied to each ICT-enabled interruption (on-task vs. off-task).	Beehr et al. (2000), Carlson (1999), Daniels (1994), Fenlason & Beehr (1994), Ganster, Fusilier, & Mayes (1986), Kaufmann & Beehr (1986), Kirmeyer & Dougherty (1988), Van Der Doef & Maes (1999)
Timing Control	Whether the individual can decide and predict when to carry out given tasks.	Whether the individual can decide when to view messages, rather than responding to intruding messages from ICTs.	Mullarkey et al. (1997) Van Yperen & Hagedoorn (2003), Wall, Corbett, Martin, & Clegg (1990), Wall, Jackson, Mullarkey, & Parker (1996), Wall, Kemp, Jackson, & Clegg (1986)
Method Control	A coping technique in which the individual can choose how to carry out the work.	Enacting control over the methods used in completing the primary task.	Mullarkey et al. (1997), Van Yperen & Hagedoorn (2003), Wall et al. (1990), Wall et al. (1996), Wall et al. (1986)
Resource Control	A coping technique to avoid the stressor by acknowledging the option to become less active and relax from work stressors.	Enacting the option to relax from the ICT environment and engage in non-ICT behaviors.	Dwyer & Ganster (1991), Edwards (1996), Karasek, Russell, & Theorell (1982), Landsbergis (1988), Yuan & Beiber (2003)

3.1. Demand Stressors

The two elements of demand (i.e., quantitative demand and message profile) are episodic. They manifest instantaneous responses in stress levels by creating perceptions of ambiguity, overload, and conflict. We justify the relationships between the demand stressors and perceptual stress in Sections 3.1.1 and 3.1.2.

3.1.1. Quantitative Demand

Quantitative demand refers to the quantity of demand (Dwyer & Ganster, 1991; Perrewe & Ganster, 1989). In this study, we focus on quantitative demand as the number of ICT-enabled interruptions that occur during an episode. Quantitative demand is high when individuals do not have time to think or talk about anything other than the task at hand (Rugulies, Bultmann, Aust, & Burr, 2006). Consistent with past research, we limit this hypothesis to evaluating relationships derived from moderate and high levels of quantitative demand[1]. The control theory of interruptions suggests that a large number of interruptions limits the ability of individuals to establish a continuous relationship with their task (Mullarkey et al., 1997), which slows a priori expectations of making progress towards individual goals and, subsequently, produces feelings of stress (Carver et al., 1990). We argue that perceptions of overload arise when interruption-based demand is in high quantity. Thus, we propose:

> **H1:** *Quantitative demand associated with ICT–enabled interruptions positively affects perceptual overload.*

3.1.2. Message Profile

In our study, message profile indicates instrumental support, which is the degree of relatedness between the interruption and the primary task (i.e., on-task vs. off-task). An instrumentally supportive interruption does not conflict with the primary task, but instead aids in the completion of the primary task by adding information (Beehr et al., 2000; Fenlason & Beehr, 1994). According to attention theory, the on-task nature of highly supportive interruptions suggests that when two tasks are related they pull from the same cognitive work sphere, thus lightening the cognitive load the individual uses to complete the task (Meyer & Kieras, 1997). By having to work through less cognitive baggage, an individual is less stressed than if his or her mind was sorting through ambiguous sources of information. This suggests that when the message is off-task, it causes ambiguity to be created from the message housed within the interruption. Also, because off-task messages impose greater demands on individual's cognitive load as compared to on-task messages, we argue that instrumental pressures arise from off-task messages because they create conflicting demand with the current task. Therefore, on-task messages limit perceptual message ambiguity and perceptual conflict, while off-task messages influence perceptual message ambiguity and perceptual conflict. Thus, we propose:

> **H2:** *Message profile positively affects perceptual conflict.*

3.2. Perceptual Stress

Stress results from the combination of perceived demands in a situation and a person's resources for meeting those demands. Perceptual stress occurs when individuals perceive adverse consequences from receiving interruptions or reading content in messages. This suggests that perceptual stress is formed from a combination of characteristics that occur at the episodic level. In a transactional perspective, these perceptions of stress occur during the primary appraisal as a result from receiving a stressor or group of stressors. As in role stress, overload and conflict can be situational in nature and act as dimensions to form the measure of stress (Carlson, 1999; Peterson et al., 1995; Pierce et al., 1993). The influence each dimension has on strain varies because the dimensions do not correlate (Nygaard & Dahlstrom, 2002). Based on stress's multidimensional nature, we disaggregate each dimension to discuss their independent relationships with strain.

---

[1] This is because low levels of quantitative demand can lead to inattentiveness, boredom, and performance decrements, which may also cause stress (Perrewe & Ganster, 1989). This suggests that, when quantitative demand is either low or high, stress occurs, while a moderate level of demand does not lead to feelings of stress. Empirical evaluation on this relationship between low quantitative demand and stress is limited.

Individuals experience episodic overload when the requirements of the task are too high and there are too many demands for the individual to fill (Tarafdar, Tu, Ragu-Nathan, & Ragu-Nathan, 2007). For example, in a manufacturing context, Dwyer and Ganster (1991) define perceptual overload as the perceptual amount of workload (i.e., "how often does your job require you to work very fast, how often is there a great deal to be done, etc.") They found that overload was associated with negative outcomes, such as tardiness and absenteeism. Our study posits that the perception of overload is directly correlated with strain. Therefore, while tardiness and absenteeism may serve as chronic outcomes that eventually occur from an individual's consistent feelings of overload, we argue that strain is an episodic outcome that results from perceiving too many ICT-enabled interruptions in a given time period.

Episodic conflict occurs when individuals perceive an incompatibility in the demand requirements, where the content of the message conflicts with the task. Specifically, when the messages conflict with the duties of the task, individuals experience intersender role conflict because two or more people are communicating expectations that are incompatible (Cooper et al., 2001; Shirom, 1982). For example, conflict occurs when the type of the profiled message (i.e., off-task message) differs from the type of the task (i.e., on-task message). Overall, when demands are in conflict with each other, we posit that individuals experience more strain. The stress to strain relationship is a well-documented part of the transactional stress process (Cooper, 1998; French et al., 1982). Thus, we propose:

H3a: *Perceptual overload positively affects strain.*

H3b: *Perceptual conflict positively affects strain.*

Technologies can enable varying objective levels of control depending on the way work is structured (Wall et al., 1990). In this study, we focus on timing control, method control, and resource control as forms of control in the transactional perspective. We limit our study to these three forms of control because they shed light into three distinct areas of our model: 1) at the onset of the stressors, 2) as an ICT-enabled coping behavior, and 3) as a non-ICT enabled coping behavior. Therefore, we focus on two elements of control derived from ICT characteristics (timing control and method control) and one general characteristic (resource control), which we operationalize as the ability to avoid the stressful ICT-enabled environment and engage in off-task behavior. These three characteristics interact with demands to manifest responses during an episode.

3.3. Solutions to Perceptual Stress

3.3.1. Timing Control

Timing control refers to whether individuals can decide when they want to view messages, rather than immediately responding to intruding messages from ICTs (Van Yperen & Hagedoorn, 2003). If individuals demonstrate control over an interruption, they predict, prepare, and exhibit timing control over their behavior (Daniels, 1994). This, in turn, minimizes perceptions of stress. Therefore, timing control allows individuals to adjust to demand by allowing them to control when they receive the ICT-enabled interruptions.

We argue that timing control over ICT-enabled interruptions will negatively moderate or minimize the negative effects from ICT-enabled interruptions on perceptual stress. This suggests that raising the level of timing control will minimize the negative effects from ICT-enabled interruptions on perceptual stress. For example, interruptions derived from "always-on" technologies (e.g., iPhone) have innate properties that make them more intrusive. This limits the degree of control individuals can attain over their time and behaviors. If an iPhone were to be programmed with timing control as a short-term characteristic, the owner would have to readjust the standard properties (e.g., turn off/silent mode). This would allow them to adjust to ICT-enabled demand by letting them control when they receive the interruptions through the technology, which would change the nature of the interruption from intrusive to passive. For example, writers sometimes leave their iPhones on while working on a major paper. A notification from their phone would automatically divert their attention away from their main goal unless their phone was turned off or on silent. If the phone was readjusted before the notification, then the writer would be more likely to focus on and finish the task at hand.

For quantitative demand and perceptual overload, timing control considers that the design of technologies allows individuals to adjust control setting rules and options, which enables them to organize their time their way. When individuals have timing control, they are better equipped to distribute their attention efficiently, which enables them to view a large number of interruptions at fewer points in time. This requires less cognition to switch attention and is therefore less stressful. Individuals have more certainty in knowing when they are to stop their flow of concentration with the primary task. By increasing the certainty, ICT-enabled timing control offsets the relationship between a high demand and ambiguity. Thus, we propose:

> **H4:** *Timing control over the ICT negatively moderates the relationship between quantitative demand and perceptual overload.*

3.4. Solutions to Strain

In the transactional perspective, when an environment is stressful to an individual, the individual will make a secondary appraisal to evaluate the environment and any alternate coping behaviors that will lessen the physiological impact on the body (Cohen, 1984). If the secondary appraisal suggests a change is desirable, the individual engages in coping behaviors, and these coping behaviors change the environment, which lessens the environment's impact of the original stressors on strain (Cooper et al., 2001). However, prior to coping, one may have less stress by just having some options available. For example, when workers are trying to finish a task, we believe the sheer availability of coping options will help lessen strain regardless of the stress of high demands. Therefore, we argue that simply having the option to cope mitigates the manifestation of perceptual stress on strain. Thus, we propose:

> **H5:** *The option to cope negatively moderates the relationship between perceptual stress and strain.*

3.4.1. Method Control

Method control is an ICT-enabled coping behavior that refers to situations in which the individual enacts control over the methods used in completing the primary task. Specifically, method control focuses on enacting the option to control how to carry out the technology-based work associated with completing the primary task (Wall et al., 1990). A lack of method control forces individuals to work in a certain way to accomplish the task. This lack of flexibility makes it difficult for individuals to manage their stress. Raising the level of method control associated with the ICT mitigates the negative effects of perceptions of stress on strain regardless of the type of stress created directly from ICT-enabled interruptions. Further, adding method control improves an individual's odds to accomplish the primary task, which reduces strain. Thus, we propose:

> **H5a:** *Method control over the ICT negatively moderates the relationship between perceptual stress and strain.*

3.4.2. Resource Control:

Resource control refers to enacting the option to step away from the ICT environment and engage in non-ICT behaviors. Resource control is independent of the ICTs and refers to behaviors associated with leaving the ICT environment (Carver, Scheier, & Weintraub, 1989). Like method control, resource control is also a function of the secondary appraisal, and is, therefore, a coping behavior. Specifically, to account for the stress at a high demand, individuals enact their option to take a break from the ICT environment to temporarily evade workplace stressors.

It is advantageous for individuals to use active coping methods to attenuate or remove the stressors completely in their environment (Carver et al., 1989; Jex, Bliese, Buzzell, & Primeau, 2001). For example, Karasek et al. (1982) point to evidence that a possible side-effect from short self-paced relaxation periods is lower heart rate and blood pressure (Landsbergis, 1988). Others have also acknowledged that resting periods, or periods when individuals can relax their mind, reduces their amount of strain (Brillhart, 2004). When individuals use resource control, they are taking advantage of clearing out their cognitive and emotional baggage associated with feelings of overload, conflict, or ambiguity. If an individual is overloaded or filled with ambiguity due to high demand or conflicted due to confounding off-task messages, providing resource control actively allows the individual to cope with actions that aid in completing the primary task and reduce overall levels of strain. Based on the arguments above, we posit that resource control serves as an active coping mechanism to decrease the manifestation of perceptual stress on strain. Thus, we propose:

> **H5b:** *Resource control (associated with escaping from the ICT environment) negatively moderates the relationship between perceptual stress and strain.*

4. Research Method

We tested our research model by conducting two laboratory experiments. We recruited participants from a large university. Participants were required to meet two qualifications: experience using ICTs regularly at home or at work and no cardiovascular problems (e.g., no known heart conditions and normal blood pressure)[2]. The latter qualification was necessary because our study manipulates participants' stress and strain.

4.1. The Experiments

Figure 3 presents the research models for the two experiments. The first experiment tested the direct effects of the objective stressors along with the interacting effect of timing control (H1 through H4). The second experiment used a separate group of participants with similar characteristics to test the moderating effects of the coping behaviors (H5). Both experiments were necessary because we had to first analyze and find a high-strain environment before we could integrate that into an experiment where participants were allowed to cope. The rationale is that participants would only cope voluntarily when they were in a high-strain environment, and, therefore, would not cope in a low-strain environment even if given the option to.

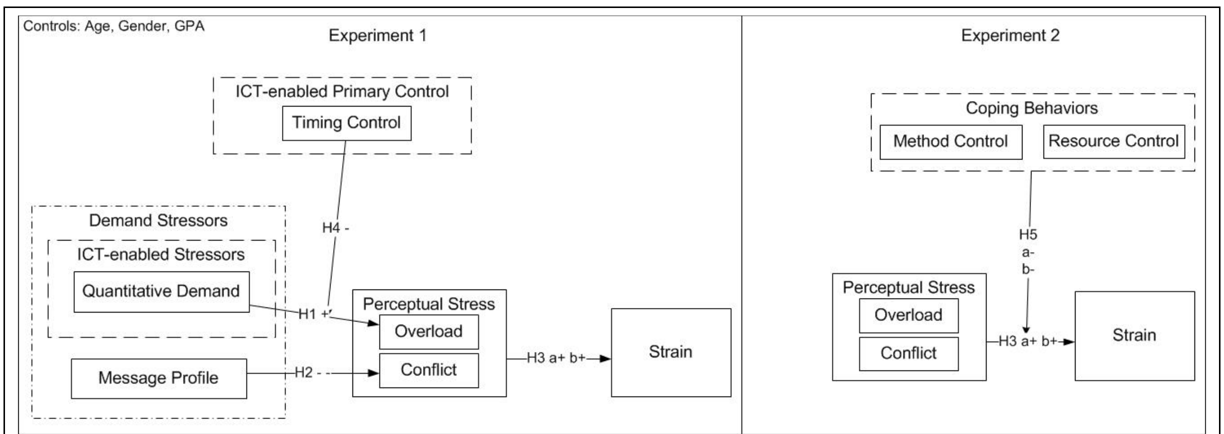


Figure 3. Research Models

We included in each experiment an episode that was formed of the same two components: 1) a primary task and 2) ICT-enabled interruptions. After pretesting various tasks, we determined that the best primary task was a standardized essay, which almost every student has the fundamental knowledge to create: it demands attention and requires participants to engage in a continuous

[2] If these issues became apparent during the experiment, we had to terminate that person's participation to protect the participant and to limit biased results in their strain measurements.

relationship with their workload (Tellegen & Atkingon, 1974) (See Appendix A for the rationale). While conducting the primary task, participants received (manipulated) ICT-enabled interruptions.

We derived the conditions manipulated in the experiment from the objective indicators (i.e., the independent and moderating variables). Table 3 illustrates that we examined all of the factors in the first experiment across units, or between-factors, at two levels.

Table 3. Experimental Conditions: First Experiment

Category	Variable	Experimental manipulation	Level
Demand stressor	Quantitative demand	**Between factor:**	
		High number of interruptions	2
		Moderate number of interruptions	1
Demand stressor	Message profile	**Between factor:**	
		Off-task / not supportive	2
		On-task / supportive	1
Primary control	Timing control	**Between factor:**	
		Email client with pop up functions	2
		Email client with control	1

For the second experiment, we examined participants' coping behaviors, which only occur in a high-stress environment (See Table 4). Therefore, we set all of the other factors that contribute to stress at high. In this experiment, we measured coping at two levels: level 1: between factor (having the option to cope), and level 2: within factor (actual coping).

Table 4. Experimental Conditions: Second Experiment

Category	Variable	Experimental manipulation
Demand stressor	Quantitative demand	**Controlled factor:** High number of interruptions
Demand stressor	Message profile	**Controlled factor:** Off-task / not supportive
Primary control	Timing control	**Controlled factor:** Email client with pop-up functions
Coping behavior	Method control	**Within factor:** Manipulation: No option to use extra informational sources Manipulation: Option to use extra informational sources
Coping behavior	Resource control	**Within factor:** Manipulation: No option to take a break Manipulation: Option to take a break

We used a before- and after-treatment experimental design, which allowed us to observe (and measure) our constructs before and after we administered the treatment (Trochim, 2004). Individuals were randomly assigned to only one group. We collected two strain data points by collecting a pre-treatment and post-treatment measure (i.e., before and after the episode) (O'Brien & Kaiser, 1985). Therefore, in our study, the change that occurred between the two time periods (time 1 and time 2) formed the actual measure of strain. This allowed us to obtain a steady baseline for each participant, which we defined as the individual's chronic level of stress in an episodically relaxed environment, compared to their post treatment, which we defined as their episodic level of stress. Therefore, participants' stress rate minus their resting rate would equal their alpha-amylase score.

4.2. Factor Structure

Table 5 shows the unbalanced block design for the first experiment. In this experiment, we had four groups of participants. Group 1 formed our "low strain" group: they had low levels of quantitative demand, an off-task message profile, and a high level of timing control. Group 2 had a high level of quantitative demand, which enabled us to test H1 (that quantitative demand leads to perceptual overload). Group 3 had off-task messages, which enabled us to test H2. We removed timing control from Group 4's participants, which also had a high quantitative demand, which enabled us to test the interaction (hypothesis 4). This was contrasted with the low demand stressors group that did have timing control (group 1).

Table 5. Factor Structure: First Experiment

Group number	Design	Quantitative demand	Message profile	Timing control
1	$QD_lMP_lTC_H$	Low	On-task	High
2	$QD_HMP_lTC_H$	High	On-task	High
3	$QD_lMP_HTC_H$	Low	Off-task	High
4	$QD_HMP_lTC_L$	High	On-task	Low

For the second experiment, we used a factor structure of a 2*1 block design (See Table 6). We evaluated coping behaviors as both the option to cope and as actual coping.

Table 6. Factor Structure: Second Experiment

Group 1	Group 2
High stress*—no coping	High stress—coping**
* In high-stress environments: QD = High; MP=High; TC = Low	
** We evaluated coping behaviors on two levels: 1) as the option to cope and 2) as enacting the coping behaviors.	

4.3. Construct Measures

4.3.1. Demand Stressors

Quantitative demand refers to the number of ICT-enabled interruptions that occur during an episode. We manipulated two levels of quantitative demand: moderate demand and high demand. We calibrated the number of interruptions per category during the pretest. After pilot testing, we found that one interruption per minute was moderately demanding and one interruption every 20 seconds was highly demanding. Appendix B shows the finalized survey of construct measures and manipulation checks.

To measure message profile objectively, we manipulated the content of the message. On-task messages provided information on the current task. For example, if the task was related to innovation, the message would help promote individual thinking along those lines. Off-task messages were formed to distract the individual from the current task, but reflected messages that organizational workers could actually receive in a real work setting. Messages were created through a multi-step process (see Appendix C).

4.3.2. Timing Control

Timing control refers to whether the individual can decide when to view messages, rather than responding to intruding ICTs. In the experiment, we administered interruptions through a simulated email client that provided the participant with the option to choose when to view a message. When the interruptions were uncontrolled, the interruptions popped up and forced the individuals to click off the messages after reading. In the first experiment, we examined timing control at two levels: high (email client with control) and low (email client with pop-up functions). See Appendix D for screenshots of the experimental tool.

4.3.3. Perceptual Stress

Perceptual stress refers to the characteristics of an episode in which the individual perceives adverse consequences. We derived the perceptual stress scale from Moore (2000) and adapted it to the interruption context (See Appendix B). It consisted of overload and conflict.

We must note the distinction between these perceptual stress items and the manipulations presented in the above sections. Manipulation checks simply determine whether the manipulation was perceived by the user. For example, in our study, we offered a high number of interruptions and a low number of interruptions as manipulations of demand variability. After they received the treatment, participants then rated items on the manipulation. We then analyzed group differences to see if the mean of the low group was significantly lower than the mean of the high group. If it was, then our manipulation was successful. Overload and conflict are subjective parts of perceptual stress where individuals rate their personal feelings as a result of the experiment. Therefore, we treated those as covariates.

In the second experiment, we set the objective conditions that evoke perceptual stress to high, so we could further evaluate the effects of coping behaviors on strain. The second experiment's perceptual stress scale, which we derived from Moore (2000) and adapted to the interruption context, is consistent with the first experiment's scale.

4.3.4. Coping

In the second experiment, we measured participants' reaction to having the option to cope and their reaction after conducting two specific coping behaviors that capture the implications of the secondary appraisal: method control and resource control. As a manipulation, method control gave the participants the ability to cope with high demand by providing them with the option to vary the method used in completing the primary task—and rather than think and type, they could use extra informational resources that aided the primary task. We adapted the manipulation check from Wall et al. (1996).

Resource control allowed participants to have the option to take a break from the ICT environment. Moreover, the group that had resource control had two minutes of built-in slack time that allowed them to choose whether and when they wanted to relax from the stressors when demands were high and stress was felt. We instructed participants that they had control over 1) whether they needed the break, 2) when they wanted to take the break, and 3) how much of the two minutes they wanted to use. We adapted some items from Dwyer and Ganster (1991), while we created others and validated them through the pretests and pilot analyses.

4.3.5. Strain

To test the outcomes of the episodic stress process in both experiments, we used alpha-amylase, a hormone produced by individuals experiencing stress. Alpha-amylase represents the state-of-the-art measures for evaluating stress and is thought to be a highly accurate measure of "real time" stress in psychological research (Rohleder, Nater, Maldonado, Kirschbaum, 2006). While the procedures and training involved in collecting alpha-amylase are quite onerous, a complete description will require far more space than permitted in a journal paper. However, we summarize the experimental process that we used to collect and evaluate alpha-amylase in Appendix E, along with more detail on timing and other features of our experiment.

4.4. Experimental Controls

Researchers have suggested that the inconsistency of empirical findings with regards to stress is due to other researcher's failure to consider individual differences (Perrewe, 1987). As such, we controlled for the effects personal characteristics have on the stress process. First, since our design revolves around ICT ability, we also gathered a measure for participants' Internet usage, Internet self-efficacy, and word processing self-efficacy. To control for extraneous variation, we gathered demographic variables while holding constant the physical environment. For demographics, we captured gender and age to test for differences in the model. Because our study involved writing ability, we also gathered GPA and class status. During the experiment, we controlled for the laboratory setting, lighting, noise, temperature, seat number, and time of day the study took place. Finally, since we were gathering objective stress measures, we also controlled for alcohol usage, caffeine usage, and sugar/dairy intake, and whether the participant had eaten a meal 60 minutes prior to the experiment. Appendix F shows the formatted survey of the control variables. Appendix G shows the approved informed consent letter.

5. Results

This section presents the pretest and pilot, followed by the experiment and results. To analyze our data, we use univariate analysis of covariance (ANCOVA) to test our hypotheses.

5.1. Pretest and Pilot Test

We conducted the pretest in two phases. It included 23 participants who participated two times (one time in each phase): 1) under a high-demand and low-control situation, and 2) under a low-demand and high-control situation. To maximize the utility from the pretests, at the end of each phase, we administered a survey to help validate our measures and calibrate our manipulations. Then, we followed up the survey with semi-structured interviews. The pretest involved a step-through analysis with participants that allowed participants to talk aloud and provide detailed feedback as necessary.

We administered the second pretest with 35 new students through scenario analysis. Since this demographic was in the sample frame, we felt it appropriate to use them for the second opportunity to revise our procedure. These participants received a packet with a description of the experiment, a screenshot of the programmed tool, and a listing of all messages. They were instructed to circle any messages that seemed ambiguous or did not help solve the task (for on-task messages) and write notes beside it about why they circled what they did.

We geared the pilot toward testing the complete design and gauging the usefulness of the manipulations. This stage used full protocol and gathered objective samples from participants. Here, we determined whether there were timing issues concerning sample collection and whether a salivary measure was appropriate for episodic manipulations. This stage involved 19 undergraduate students. During the pilot, we collected and analyzed both cortisol and alpha-amylase measures. From the survey data, we calculated Cronbach's alphas for the constructs. After careful analysis, we changed six items that were the cause of low alphas. We also modified construct items that resulted in extraordinarily high scores (.97 or greater) because we determined that we were measuring the same thing with each item as opposed to tapping into a wider spectrum of the construct. This only occurred with items for perceptual overload and perceptual conflict[3] .

5.2. Experiment and Results

Informed by our pilot study, we conducted the full experiment in the spring of 2009. To test our research model, we broke the full experiment into two smaller experiments, each using participants from the same sample frame. Therefore, to test the research model, we used our protocol to collect data from 180 total undergraduates (90 participants in each experiment), established the validity of our measures, and tested our hypotheses. To improve validity, we ensured that the test had good

[3] As we made changes to the survey during the pilot, we re-ran the reliability analysis on all items after collecting 50 more data points. Once we decided that their values were acceptable, we concluded that the items were valid and reliable.

statistical power, reliability, and implementation (Trochim, 2004). While there were two experiments, to avoid contamination of the results, each participant could only take part in one experiment or the other.

5.3. Sample Characteristics

Table 7 shows the descriptive statistics of the overall sample. A total of 180 students participated between the two experiments. We chose our sample based on individuals' homogeneity of IT usage patterns and their ability to multitask with IT (and, thus, their ability to handle interruptions). They averaged a high self-efficacy (ISE = 0.766; WPSE = 0.938), which had a small standard deviation[4]. Over 70 percent of our sample self-reported having used the Internet for over eight years. Over 80 percent of our sample reported using the Web frequently. More men than women participated in the experiments. Participants' average age was slightly over 21, which is typical of college-aged students. The majority were caucasian/non-hispanic third-year and fourth-year students. Their GPA varied widely with 54.4 percent above a 3.0 average (from a maximum of 4.0).

Table 7. Descriptive Statistics of the Overall Sample

Gender	Male (61.1%)		Female (38.9%)	
Age	Mean: 21.19		Standard deviation: 1.967	
Internet self-efficacy (ISE)	Mean: 7.66		Standard deviation: 1.788	
Word processing self-efficiency (WPSE)	Mean: 9.38		Standard deviation: .879	
GPA	3.5 or greater 18.3% (N=33)	Between 3.0 and 3.5 36.1% (N=65)	Between 2.5 and 3.0 26.7% (N=48)	Less than a 2.5 18.9% (N=34)
Years using the Internet	Greater than 8 years 71.1% (N =128)	Between 4 and 8 years 28.3% (N =51)	Between 2 and 4 years .6% (N =1)	Less than 2 years 0% (N =0)
How often do you use the Web to search for information?	Very often 81.7% (N=147)	Often 17.2% (N=31)	Some .6% (N=1)	Little to none .6% (N =1)
Class status	First year 1.7% (N = 3)	Second year 26.1% (N = 47)	Third year 32.2% (N = 58)	Fourth year 40.0% (N = 72)
* We measured ISE and WPSE on a 10-point scale (not confident at all to totally confident).				

5.4. Reliability and Validity Analysis

Table 8 reports the means, standard deviations, factor loadings, reliabilities, and number of items for the entire sample of 180 participants. While we examined the data for demographic differences between the two experiments, we found that our samples were relatively homogenous between the two studies; therefore, we present the demographics together for the entire research model.

To test for measurement error, we conducted both an exploratory factor analysis (EFA) in Statistical Package for the Social Sciences (SPSS) and a confirmatory factor analysis (CFA) using Structural Equation Modeling Software (EQS). Appendix H shows the EFA results. In our CFA, we found that our model resulted in a chi-square value of 297.511 (p-value <.001), a comparative fit index (CFI) of .97, and a root mean-square of approximation (RMSEA) or .043. To be a good model fit, the chi-square value must have a significant p-value, the CFI should be above .9, and the RMSEA should be

[4] We ended up deleting ISE and WPSE as control variables in our analyses because our sample did not significantly vary in response.

below .06. All of our values passed the requirements, which points to good model fit and confirmed our factor analysis. We show the item loading range of our indicators below. We also calculated each construct's Cronbach's alpha, which should be greater than .7 before it can be combined for a scale.

We assessed the constructs' properties in terms of item loadings, discriminant validity, and internal consistency. Item loadings and inter-construct reliabilities greater than .71 are considered excellent, while greater than .63 is considered very good, .55 is good, and .45 is fair (Comrey & Lee, 1992). Most of our items were above the very good threshold. One item, QD1, was only fair. After further evaluation, we kept this item in the analysis after examining the Cronbach's alpha, which would not change if the item was scaled out.

Table 8. Construct Measures

Construct	Mean	Standard deviation	Item loading	Cronbach's alpha	Number of items
Quantitative demand (QD)	3.849	.7902	.538 - .828 QD1, QD2, QD3	.707	3
Message profile (MP)	2.014	.9458	.851-.868 MP1, MP2	.777	2
Timing control (TC)	2.569	1.240	.738-.856 TC1, TC2, TC3	.768	3
Overload (O)	3.754	.9678	.723-.755 O1, O2, O3	.882	3
Conflict (C)	3.3966	.9662	.750-.755 C1, C2, C3	.825	3
Stress (S)	2.482	.8116	.628-.880 S1, S2, S3, S4, S5	.896	5
Method control (MC)	2.212	1.0924	.845-.845 MC1, MC2	.856	2
Resource control (RC)	2.778	1.331	.803-.888 RC1, RC2, RC3	.865	3

Convergent validity suggests that items load highest on the construct of interest (Campbell & Fiske, 1959). Our results indicate that each item loaded highest on the appropriate construct. Next, we assessed discriminant validity by evaluating whether item loadings were higher on the construct of interest than the remaining constructs. Our results suggest that items loaded highest on the constructs of interest, which provides of convergent and discriminant validity. Second, we examined the average variance extracted (AVE) of each construct. Convergent validity exists when a construct's AVE is at least .5, which each construct exceeded (Fornell & Larcker, 1981). To be discriminant, the square root of the AVE should be greater than inter-construct correlations (Agarwal & Karahanna, 2000; Chin, 1998). As Table 9 shows, each construct shares more variance with their respective indicators than with other constructs. Thus, our results suggest convergent and discriminant validity in the measurement model, and provide evidence of the reliability, convergent, and discriminant validity of our measures.

Table 9. Inter-Construct Correlations								
	QD	MP	TC	O	C	S	MC	RC
Quantitative demand	.807							
Message profile	-.429	.705						
Timing control	-.351	.270	.843					
Overload	.770	-.274	-.348	.861				
Conflict	.669	-.447	-.276	.836	.836			
Strain	.609	-.330	-.256	.564	.627	.855		
Method control	-.077	.016	-.149	.001	.012	390	.896	
Resource control	-.133	-.027	-.102	-.205	-.127	.049	.641	.921
*The numbers on the leading diagonal are the square root of the average variance shared between the constructs and their measures. The non-diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be larger than non-diagonal elements.								

5.5. Techniques

To test the model proposed for the first experiment, we used analysis of covariance (ANCOVA) statistics (see Figure 4). We tested the first part of the model between demand stressors to perceptual stress (model 1A). Second, we tested the model between perceptual stress to strain, which we measured using alpha-amylase (Model 1B). For the first experiment, we included age, GPA, and class status as control variables. For the second experiment, we ran two different analyses. For the second experiment, using an independent sample *t*-test, Model 2a tested the overarching hypothesis of the option to cope on strain. Finally, we tested the coping behaviors that occurred in the experiment, Model 2B used ANCOVA to test the interaction of resource control and method control on stress to strain.

5.6. Assumptions

An underlying assumption of ANCOVA suggests that the distribution must be normal. Many biometric researchers take the square root transformations of alpha scores that violate this assumption. While positive skew is less problematic when the collection device is placed in the same specific area of the mouth (i.e., the left cheek) (Harmon, Towe-Goodman, Fortunato, & Granger. 2008), we still conducted a square root transformation on our data to limit the variance between subjects objective measures of strain. After transforming the data, we deleted one outlier that was three standard deviations above the mean. Finally, we refused 17 alpha-amylase scores from the experiment where subjects violated at least two of the sample controls listed in Table 10. This left us with 179 usable survey results and 162 corresponding alpha-amylase scores.

Table 10. Sample Characteristics		
Have you had alcohol in the last 24 hours?	Less than 2 drinks 88.3% (N = 159)	3 drinks or more 11.7% (N = 21)
Have you had caffeine in the last 2 hours?	None to some caffeine 98.9% (N = 178)	A lot of caffeine 1.1% (N = 2)
Have you had any dairy products or high fructose foods 20 minutes prior to the study?	No 86.7% (N = 156)	Yes 13.3% (N = 24)
Have you eaten a major meal 60 minutes prior to the study?	No 79.4% (N = 143)	Yes 20.6% (N = 37)

5.7. Manipulation Checks

Next, we provide the descriptive statistics of our experimental conditions (see Table 11) and examine our manipulation checks for our treatments in Table 12. As we specify previously, in the first experiment, we had four groups.

Table 11. Descriptive Data of Experimental Conditions

Group number	Design	N	Quantitative demand	Message profile	Timing control
1	$QD_{I}MP_{I}TC_{H}$	18	2.907 (1.047)	2.861 (1.082)	4.204 (.8792)
2	$QD_{H}MP_{I}TC_{H}$	11	3.848 (.7939)	2.727 (1.697)	3.485 (1.345)
3	$QD_{I}MP_{H}TC_{H}$	11	3.576 (.7317)	2.045 (.8208)	3.273 (1.432)
4	$QD_{H}MP_{I}TC_{L}$	26	3.936 (.6255)	2.442 (.8869)	2.513 (1.088)

To test for successful manipulations, we used independent samples *t*-tests (Student, 1908). We were only interested in comparing two groups at a time (group A when the stressor was low and primary control was high, and group B when the stressor was high and primary control was low). We found all of the manipulations to be successful (see Table 12).

Table 12. Manipulation Checks

First experiment							
Comparison factor	**T-statistic**	**Degrees of freedom (DF)**	**Mean group A**	**Mean group B**	**Mean difference**	**Std. error difference**	**P-value**
Quantitative demand	2.560	27	2.907	3.848	.94126	.3677	.016
Message profile	2.146	27	2.861	2.045	.81570	.3801	.041
Timing control	5.466	42	4.204	2.513	1.6909	.30934	.000
Second experiment							
	T-statistic	**Degrees of freedom (DF)**	**Mean for group with no coping**	**Mean for coping group**	**Mean difference**	**Std. error difference**	**P-value**
Resource control	7.486	86	2.265	4.136	1.8712	.2499	.000
Method control	4.908	86	1.977	3.114	1.1364	.2315	.000

5.7.1. First Experiment

Table 13 presents the results on the hypotheses relating to the demand stressors (H1, H2), the perceptions of stress (H3a and H3b), and primary timing control (H4). First, we examined between subjects' tests and found our demand stressors construct, including all groups, to be significant.

Table 13. First Experiment's Hypotheses

Hypotheses	Independent variable	Dependent variable	Mean square	F-statistic	P-value	Observed power
H1	Quantitative demand	Overload	78.873	135.362	<.001	1.0
H2	Message profile	Conflict	12.506	14.251	<.001	.964
H3a	Overload	Strain Alpha-amylase	5.840 13.468	13.347 4.459	<.001 .028	.953 .555
H3b	Conflict	Strain Alpha-amylase	6.869 20.762	6.837 6.873	.010 .042	.976 .741
H4[5]	Quantitative demand * timing control	Overload	2.311	3.967	.048	.508

Next, we examined the parameter estimates of this model to see the change in factor from moving up one unit on the independent variable (see Figure 4). Overall, all of our results were significant. Specifically, quantitative demand significantly lead to overload (H1: Δβ = .823, *t*-statistic = 11.635, p-value <.0001) and message profile significantly decreased conflict (H2: Δβ = -.272, *t*-statistic = 3.775, p-value <.0001). Our results suggest that our hypotheses were significant when considering both perceptual and objective strain. Specifically, strain measures were significantly higher when participants were overloaded (H3a: alpha-amylase: Δβ = .208, *t*-statistic = 2.122, p-value <.05; perceptual strain: Δβ=.262, *t*-statistic = 3.653, p-value <.0001). In terms of conflict, strain measures were significantly higher when participants were conflicted (H3b: alpha-amylase: Δβ = .551, *t*-statistic = 2.622, p-value <.01; perceptual strain: Δβ = .297, *t*-statistic = 3.962, p-value <.0001). Finally, timing control significantly interacted with quantitative demand to lessen overload (H4: Δβ = -.025, *t*-statistic = 1.992, p-value =.048).

Age and GPA were significant control variables in model 1a when using conflict as a dependent variable (Age: Δβ=.128; *t*-statistic: 9.205; p-value <.001; GPA: Δβ = .289; *t*-statistic: 4.594; p-value <.001). Age was only a significant control predictor in model 1b when using perceptual strain (Δβ=.028; t-statistic: 2.615; p-value <.01) as a dependent variable. Specifically, an older participant will receive more conflict and feel more perceptual strain. Also, a participant with a higher GPA will feel more conflict. We dropped the other control variables from the analysis because they were not significant (i.e., class status, ISE, and WPSE).

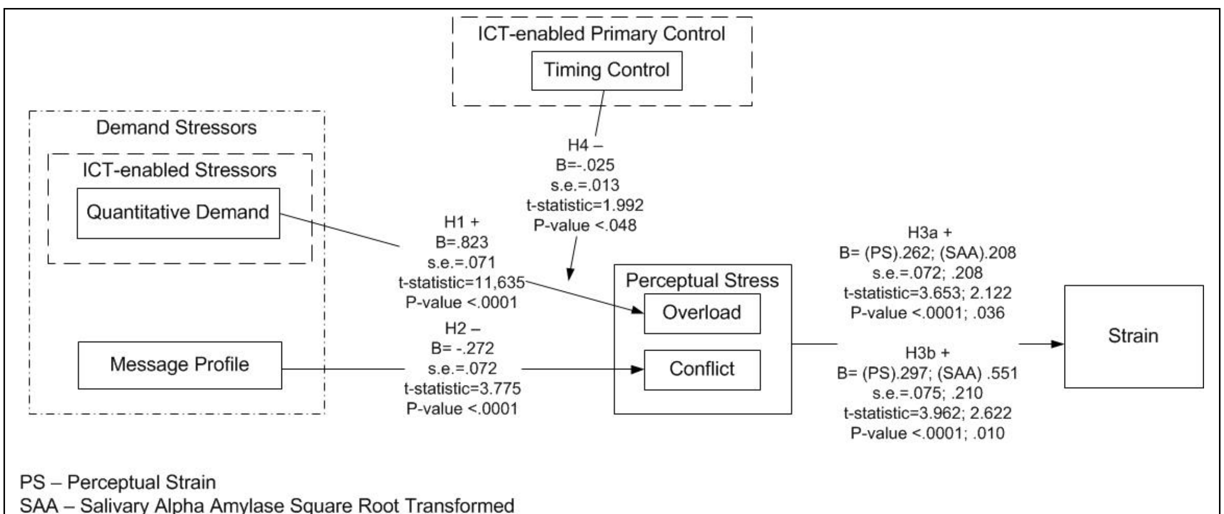


Figure 4. First Experiment's Results: Model 1A and 1B

[5] Note that we included timing control as a main effect prior in the ANCOVA while testing the interaction. However, we do not explicitly discuss it since we did not theorize it.

5.7.2. Second Experiment

In the second experiment, we allowed participants to cope. First, we checked for group differences in strain between coping and not coping with the option to cope. Overall, the results suggest that the option to cope significantly lowers alpha-amylase (see Table 14). When we did not allow participants to cope, participants alpha-amylase went up by .960 standardized units (H5: t-statistic = 2.128; p-value < .05). When we tested the same model with perceptual strain, we found the option to cope or actual coping had no effect (H5a and H5b: N.S. for perceptual strain).

Table 14. Second Experiment's Overall Model Results: Model 2A

Hypotheses	Independent variable	Dependent variable	Mean coping	Mean no coping	Mean difference	T	Df	p-value
H5	Coping Options	Perceptual Strain	2.65	2.560	.095	.556	86	.931
		Alpha-Amylase	.354	1.314	.960	2.128	76	.037

After we found significant group differences between the option to cope and strain, we then examined the relationship overload and conflict had with strain when subjects either enacted resource or method control behaviors, or when subjects did not. Therefore, the next model tests a within-treatment from the subjects in the coping option group (N = 44). This model allowed us to test the added benefit from only those who enacted the behavior after given the choice and those who did not enact the behavior even if they had the choice to. Table 15 presents the results.

Our results suggest that method control increases the relationship between overload and alpha-amylase (H5a: alpha-amylase: Δβ = 1.833; *t*-statistic 3.252; p-value .003), while decreasing the relationship between conflict and alpha-amylase (H5a: alpha-amylase: Δβ = -1.985; *t*-statistic 3.109; p-value .004). On the contrary, resource control decreases the relationship between overload and alpha-amylase (H5b: alpha-amylase: Δβ = -1.429; t-statistic 2.525; p-value .016), while increasing the relationship between conflict and strain (H5b: Δβ = 1.691; alpha-amylase: *t*-statistic 2.664; p-value .012). Neither method control nor resource control had an interaction between perceptual stress and perceived strain.

Table 15. Second Experiment's Results of Coping Participants: Model 2B

Hypotheses[6]	Interaction variable	Strain	Alpha-amylase
H5a: method control	Overload	β= -.462; Std. Error .371 t-statistic = 1.247; p-value .220 Observed Power: 229	β= 1.833; Std. Error .564 t-statistic = 3.252; p-value .003 Observed Power: .885
	Conflict	β= .732; Std. Error .418 t-statistic =1.752; p-value .087 Observed Power: .401	β= -1.985; Std. Error .639 t-statistic = 3.109; p-value .004 Observed Power: .856
H5b: resource control	Overload	β= .549; Std. Error .368 t-statistic = 1.492; p-value .144 Observed Power: .307	β= -1.429; Std. Error .639 t-statistic = 2.525; p-value .016 Observed Power: .690
	Conflict	β= -.530; Std. Error .411 t-statistic = 1.288; p-value .205 Observed Power: .242	β= 1.691; Std. Error .635 t-statistic = 2.664; p-value .012 Observed Power: .736

[6] To compare, we also ran a regression using MC, RC, O, C, MC*O, MC*C, RC*O, and RC*C as coefficients. In running, we excluded RC, O, and C from the model. We maintained MC, MC*O, MC*C, RC*O, and RC*C; however, MC did not have a significant relationship with strain (Δβ = .653; *t*-statistic 1.942; p-value n.s.). The interaction of coping variables and perceptual stress all significantly lead to strain. Specifically, MC*O had a standardized β of 3.087 (*t*-statistic 3.082; p-value < .005). MC*C had a standardized β of -3.093 (*t*-statistic 3.573; p-value < .001). RC*C had a standardized β of 3.110 (*t*-statistic 2.934; p-value < .01). Finally, RC*O had a standardized β of -3.083 (*t*-statistic 2.802; p-value < .01). The regression analysis proved consistent with the ANCOVA results presented above.

6. Discussion

Overall, we found strong support for the majority of the hypotheses. Our results suggest that ICTs create stress, which leads to strain, but that control factors mitigate the relationship between stress and strain (see Figure 6 for results from both experiments).

Out of the five broader hypotheses, we found support for the first experiment and partial support for the second. Based on the individual hypothesis test results, we can offer some interesting conclusions. It was clear, for instance, that strain was higher when participants were overloaded. This relationship has been examined in stress research and our finding was consistent with past research (Perrewe, 1987), even though the setting was novel. In our context, the significance of perceptual overload as a strong predictor of strain implies that individuals have a difficult time managing the demands from a high number of ICT-enabled interruptions. Therefore, the sheer quantity of interruptions stresses individuals regardless of what the message says or how the message is portrayed to the individual.

Second, we found that conflict contributes to strain. This finding suggests that, when individuals feel stress from a message, conflict resulting from off-task messages with the primary task may be enough to influence strain.

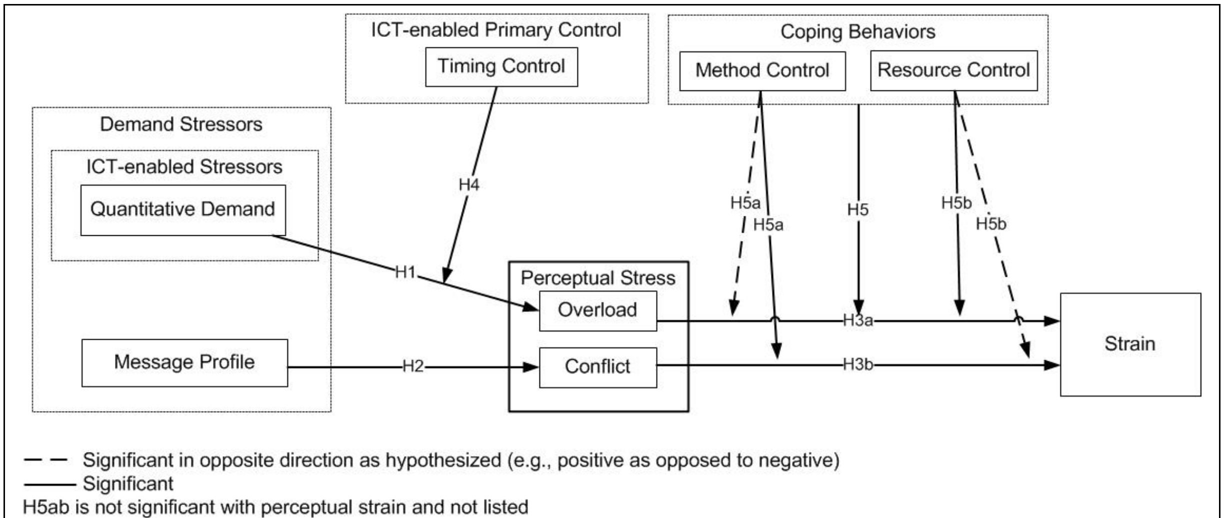


Figure 6. Summary of Findings

We found support that both the option to cope helps overcome physiological responses to stress, and that individual coping behaviors can also help or hurt depending on the situation. Specifically, we found support for the general coping hypothesis when it came to objective strain. We conclude that the option to cope helps overcome physiological responses to stress. In terms of specific coping behaviors, we examined two influences on strain: 1) the interaction of method control with stress, and 2) the interaction of resource control with stress. We determined from both coping behaviors that the best way to mitigate strain was to step away from the ICT environment. Specifically, we found that having control over the method may increase overload while decreasing conflict. Accessing and using additional complimentary resources may be beneficial to finishing a primary task. This reduces conflict because one's methods are tied to the primary task, which consequently increases the clarity of the individual's goal. However, this can also cause overload because now the individual has more workload to deal with.

Second, we found that taking a break mitigates overload's relationship with stress, while also increasing conflict. This finding opposes method control. Resource control allows individuals to break, clear their heads, and start fresh, which then gives them the positive feeling to get work done, which reduces the feeling of overload. However, when individuals take a break knowing that they have work to do, at the same time, they can also become conflicted and, thus, more strained.

In the front-end of the model, we argued that perceptual stress is manifested in overload and conflict, and results from the demands in an environment and the resources available to a person to meet those demands. Our results indicate that quantitative demand significantly led to overload. This suggests that, when ICT-enabled interruptions were more frequent, individuals felt greater stress due to overload where the task demand exceeded the resources they had to cope. Next, we tested whether timing control over ICT moderated the relationship between quantitative demand and perceptual overload. We found that, when participants were exposed to a high quantitative demand, stress responses were significantly higher in the absence of timing control as opposed to when participants had timing control. This suggests that a high number of invasive interruptions are more problematic than controlled interruptions.

We also posited that having an off-task message profile positively affects perceptual conflict. Our results suggest that conflict was significantly higher when messages were off-task. This suggests that messages unnecessary to the completion of the task at hand make individuals experience an incompatibility in demand.

6.1. Limitations

Our study's primary limitation stems from our sample frame. Our participants were students who used ICT regularly and had no obvious health problems. By selecting college-aged individuals with no known health problems (μ = 21), we may have biased the results and thus diminished our chances of finding significant results. As individuals grow older, their bodies experience further chronic wear and tear and are thus more susceptible to strain from episodic stressors (Marin et al., 2007). Working individuals still have to experience interruptions whether they are "healthy" or not. Thus, by limiting our search to young individuals, we may have limited our result's generalizability to the broader population. Even though we simulated a working environment in the experiment and found significance in our model, our results may have been more remarkable had we not limited our sample frame. Future researchers should consider replicating this study with different age groups to try to capture more variance in the results.

Second, our study focused on stress as an outcome of demands, control, and coping. Because we tested the entirety of the stress model, we limited our study of additional outcome variables, such as performance. In the future, researchers could collect an objective measure of performance and compare that measure to the amount of stress their body receives after working with an ICT-based task.

Third, we theorized only the negative form of stress, distress, which we term strain controlling for the positive form of stress, eustress. The response-based perspective of stress suggests the arousal of the autonomic nervous system results in two forms of stress: distress and eustress (Stein & Cutler, 2002). Distress arises from negative reactions, and is the key factor in influencing illness. Eustress is positive stress, including facets like exercise, increased excitement, and learning, similar to our active quadrant in the demands control model. Eustress is related to sought-after encounters in a person's life, but can be just as easily taxing on the body if not controlled (Lazarus, 1993). For example, while short periods of increased physical arousal through exercise are good, prolonged continuous exercise can also lead to negative results (i.e., increased fatigue and stress on the body). Lazarus (1993) found that eustress and distress could be broken up further and understood by emotion, where eustress includes feelings of happiness, pride, relief, hope, love, and compassion; and distress includes feelings of anger, anxiety, fright, guilt, shame, sadness, envy, jealousy, and disgust. In the future, researchers could try to understand eustress alongside distress. Then, researchers may be able to prescribe ways to channel distress into eustress.

Finally, we found H5a and H5b to be significant only when considering objective strain. While our scale showed signs of reliability, convergent validity, and discriminant validity, it may be possible that newer more-contemporary scales may be better suited for an experiment on objective strain to correlate more strongly with the objective measure. Future researchers should use caution before adopting our strain scale.

6.2. Implications for Research

This paper has several implications for research. We argue that this paper makes a contribution to stress theory because a) it brings together different components (i.e., relationships, constructs, etc.) of stress found and tested in different fields (i.e., psychology, organizational behavior, health) and examines the pieces as an integrative process; b) it is not obvious how formalized stress theories apply to an IS context. The integrative model we tested is contextualized in IS and can form the foundation of an IS-based theory of episodic stress; and c) Most IS-induced stress research is role-based; we offer a model of episodic stress that is critical in contemporary environments where digital interruptions are commonplace; and d) while there are many theories on stress, we contextualize one that has a formalized (and complete) process; further, we had the means and the ability to test it all the way from beginning to end.

Specifically, we articulate and test a fresh model of stress after following the suggested period of "quiet reconstruction" (Cooper et al., 2001, pp. 23). We examine components of both the demands control theory and the PE fit model in our integrated transactional model of stress. The transactional perspective allowed us to categorize control as primary or secondary (i.e., coping behavior). In this perspective, the PE fit model helped us understand the fit between a person and an environment while those people received stressors given a certain level of supplies. While most IS research on stress (Raghu-Nathan et al., 2008) draws from organizational theories to study role-based perspectives of stress, we examine episodic stress and frame it in an information technology/interruption context. In doing so, we combine and integrate theory from a variety of fields that are able to shed insight into the model from a unique point of view. This included theory on episodic stress (Selye, 1956, 1983, 1993), interruptions (Speier, Valacich, & Vessey, 1997; Speier et al. 1999), and technostress (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). We also had to examine strain research to find a testable outcome variable that truly defined episodic strain (Gordis, Granger, Susman, & Trickett, 2007; Granger et al., 2007). While the transactional perspective has been used to theorize models of strain in many fields, rarely has it been theorized and examined from the point of the objective stressor to the reactions of stress. Therefore, we believe that the contribution of this study is in its construction and testing of a fairly complete model of interruption-based stress: as such, it lays the foundation for understanding how contemporary ICT environments can create strain in individuals.

Since we integrated theory from referent fields, this study could be of interest to both the psychology field and the general health sciences. Psychology examines cognitive states and individual traits, including the theoretical underpinnings of the demands control model. We expanded the application of the demands control model by adapting it to a new context at the episodic level and by studying specific ICT-enabled demand stressors and control/coping behaviors that affect the link between demand stressors and strain. In doing so, we directly assessed how manipulation of ICT yields physiological changes, an aspect rarely examined in the psychology literature. The health sciences provide a physiological understanding and assessment of strain that we used in this study. The ICT context and the timing of physiological measures at the episodic level provide a roadmap into how health studies can be integrated into management studies. Specifically, we believe that using alpha-amylase offers tremendous promise in measuring strain over traditional survey-based measures.

Our focus on ICT-enabled interruptions alongside stress provides the groundwork for researchers to advance our understanding of this pervasive phenomenon in the future. There could be some refinements in the model tested in the study. As we discuss in the limitations, while we believe that individual bodies react the same way to stressors, older, less techno-savvy individuals' stress levels could be higher than the population that we sampled. Future researchers could consider replicating this study with different age groups to try to capture more variance in the results.

We only tested two demand stressors and three control factors that we believe helps lay the foundation for studying technostress. We recognize that there may be some interactions occurring that we did theorize and that were outside our scope. For instance, perhaps a high quantity of off-task messages (quantitative demand * message profile) interact to produce higher levels of overload: a high number of off-task messages could cause a constant distraction, eliminating the time needed for an individual to refocus on the primary task. Future researchers could continue to examine a greater span of technology grounded demand stressors along with more-informative two- and three-way interactions to understand the full impact of the technostress phenomenon.

In this study, we captured one characteristic of a message profile (on-task vs. off-task); however, there may be other characteristics that we did not examine (Parkes, 1986). For instance, messages that are on-task could also be operationalized as “substantive” in nature. Specifically, sometimes, an incoming message complements the project that is currently being worked on, but additional demands are associated with them (such as those that would improve performance on the task). On the one hand, this could decrease stress because the on-task substantive interruptions provide more quality information on the task at hand. On the other hand, these messages can induce stress because they are received with extra demand needed to complete the task. Second, message profile could be examined by the source of the message support. For instance, if the message is from a supervisor instead of a peer, the message could be deemed more important, but also as having higher demand. This source of the message suggests that the transaction is interpersonal in nature (Carlson et al., 1999). In an organization, different sources can provide more aid in reducing ambiguity surrounding an event; specifically, a supervisor can be more helpful than a peer. While peers may provide support, because the supervisor is in charge of the individual’s work goals, the supervisor’s message has an automatic level of priority attached to it, which reduces uncertainty. For example, when a supervisor (i.e., who is in charge of their employees’ task requirements) interrupts an individual, regardless of the actual message content, the individual does not feel conflict surrounding the interruption because the difference in power automatically deems the current interruption more important than the task. By sending an interruption to the employee, the supervisor requires that the interruption take priority over the current task. With peers, while the message may be related to the primary task, it may not be agreeable with what the supervisor would suggest as “on-task”, which makes the goals of the primary task more difficult to attain. With limited uncertainty involved in deciding whether the individual should halt the primary task and read and agree with the supervisor’s message, there is less likelihood of negative effects. Following this logic, since the interruption is automatically prioritized, it is no longer in conflict with the current task, but instead evokes lower demand than an off-task message.

This paper contributes to methods by embedding a multi-method approach in its experimental design to capture the longitudinal stress process. To our knowledge, we are among the first behavioral science researchers to use alpha-amylase to test for differences from ICT-enabled stressors. Experimental designs are superior to survey design because they engender confidence in meeting the causality assumption. Our design was particularly effective because, in each hypothesis, we captured the two constructs being tested with a unique technique. Specifically, we manipulated the enabling technology and related it to perceptions (objective to perceptual). Then, we related the perceptual outcomes to the objective outcomes. This technique significantly reduced method bias. We believe that additional objective measures of strain may help enrich our understanding of technostress. For example, health literature informs us that blood pressure, pulse, and the interaction of cortisol with alpha-amylase may add explanatory power to understanding physiological changes (Gordis et al., 2007). Specifically, researchers can explore additional measures, such as cortisol, when continuing technostress research in the future, particularly when they move from episodic to chronic stressors.

6.3. Implications for Practice

This paper has several implications for managers seeking to ameliorate some of the deleterious effects of ICT-enabled interruptions their workers feel (see Table 16). First, managers need to determine ways to organize priorities so that they can handle on-task vs. off-task interruptions

(Seshadri & Shapira, 2001). In addition, they can also prescribe specific tools to their workers that will automatically filter through messages. For instance, priority flags, RSS feeds, and email groups can dramatically help lessen the time spent sorting through information. Workers can use clients such as Outlook to set up rules that will automatically place emails into folders to assist in detecting important information (perhaps messages from their boss or messages flagged as urgent). Managers can review policies with employees in advance to better articulate their definition of an urgent message versus a low priority message, thus preventing uncertainty in the future. This can also clarify the ambiguity problem that workers feel from messages being on-task or off-task because they can associate the message with an importance level. Effective programs, such as Doodle, also lessen the quantity of messages by providing a means for groups to schedule times in advance without weighing through multiple emails of response times.

Second, our findings underscore the beneficial effects of giving employees control over when they perform behaviors. Business magazines have repeatedly suggested that loss of control is the number one factor in workplace stress[7]. Our results confirm that a loss of control does lead to stress. However, our results extend these anecdotal assertions by also suggesting that characteristics of the enabling technology encourage employees to feel this loss of control, while other factors allow individuals to enact coping behaviors that can help overcome ICT-enabled strain. Specifically, when workers experience interruptions, they often feel out of control, but even more so when the ICT-enabled interruptions are invasive[8]. Also, when overloaded by ICTs, it is best for individuals to step completely away from the ICT environment. Therefore, giving workers control over timing not only helped by allowing individuals to turn off invasive interruptions, but also by serving as a coping behavior and allowing individuals to remove themselves from stressful ICT environments during times of stress.

In addition, we reiterate that the key variable here is not about having a break; rather, it is about allowing workers to choose when they need this break (e.g., during the time when they feel most stressed). Management should consider that the main way to reduce stress is to provide flexibility in timing and encourage short amounts of time away from the computer. Then, managers should encourage workers to try to relax during these breaks. These breaks during work hours should help reduce any of the workers' cognitive baggage and let their minds reset with lower stress levels. Overall, we conclude that, by giving workers more autonomy over enabling technology and allowing them to cope with the technology, management can help eliminate strain at the source of the stressors.

Finally, we believe that, if workers cannot take a break and are stressed, they should change their method of working. Specifically, we found that giving participants control over their method of working with the technology significantly lowered their levels of strain. We did this by giving them access to anything on the Web, which allowed the participants to search for additional information that could help them finish their task. While this may make workers more overloaded, it reduces their feelings of conflict. Management should be flexible and allow workers to use online sources that will help them get the job done.

Workers and managers should hold informal meetings to discuss potential helpful (and not stressful) ICT tools that may help streamline the workload and enhance communication between parties. By understanding and limiting these workplace stressors and by increasing control in the environment, we hope that organizations can enhance the business productivity and profitability of their employees.

---

[7] See: http://www.businessknowledgesource.com/blog/top_10_causes_of_workplace_stress_000810.html
http://ezinearticles.com/?Overcome-the-Top-10-Causes-of-Workplace-Stress&id=1202

[8] Many contemporary websites use pop-up ads that are invasive and out of the user's control.

Table 16. Implications for Practice

Finding	Implications for management
Organize ways to set priorities	Management should encourage proper time management and clearly delegate responsibilities with interruptions. Specifically, managers should set rules for themselves and their employees on how to handle incoming ICT interruptions. ICT tools can help (e.g., priority flags, RSS feeds, email rules, scheduled interruption (email) time).
Many forms of control help to overcome stress	When stressed by ICTs, it is best for individuals to step completely away from the ICT environment all together. However, if workers cannot take a break and are stressed, they should change their method of working. Managers should allow for such flexibility in intensive ICT-oriented environments.
Coping with technology can add stress if not used appropriately.	Workers should be careful that they are not creating any more stress when they are adding behaviors that sometimes help them cope.

7. Conclusion

Although previous research in the IS literature has examined perceptual stress at a chronic level, researchers have yet to examine objective strain, specific demand stressors, and specific coping behaviors that mitigate strain at an episodic level. We offer new avenues to IS researchers by 1) developing a theory-based model of how objective characteristics of technology influence the stressor/strain relationships, and 2) testing that model using best practices from health-related fields that examine stress. Our study takes a more-nuanced view of ICTs and directly models how ICT-enabled interruptions influence individual stress when performing a task. In doing so, we integrate episodic stress and technology with interruption-based research and explain how technology induces stress in individuals. We also examine possible coping behaviors that show how ICTs can also be used to diminish the stress evoked by interruptions.

Contemporary ICT environments are stressful with a variety of interruptions vying for individual attention. Knowledge workers are increasingly working long hours in such environments. Systemic ways for organizations to manage resulting stress at the episodic level is not only relevant, but also important for businesses that seek to improve individual and organizational productivity. We hope that future researchers will continue to build on this work by exploring different demand stressors and coping behaviors as well as specific impacts on productivity.

Acknowledgments

We thank Dr. Richard Pak and Dr. Kristin Scott for their advice and support during the study. We also thank our salivary assay company, Salimetrics, who provided very useful knowledge of stress hormones and their implications to our study. We are particularly grateful to Dr. Douglass Granger, who allowed us to gather his opinions on alpha-amylase. We also thank my student assistant, Caroline Long, for her help in proctoring the study. Finally, we thank Creative Inquiry @ Clemson for funding the project.

References

Agarwal, R., & Karahanna, E. (2000). Time flies when you're having fun: Cognitive absorption and beliefs about information technology usage. *MIS Quarterly, 24*(4), 665-694.

Aldwin, C. M. (2007). *Stress, coping, and development: An integrative perspective* (2nd ed.) New York, NY: The Guilford Press.

Ayyagari, R. (2007). *What and why of technostress: Technology antecedents and implications* (Doctoral dissertation). Clemson University.

Ayyagari, R., Grover, V., & Purvis, R. (2011). Technostress: Technological antecedents and implications. *MIS Quarterly*, *35*(4), 831-858.

Beaudry, A., & Pinsonneault, A. (2005). Understanding user responses to information technology: A coping model of user adaptation. *MIS Quarterly*, 29(3), 493-524.

Beehr, T. A., Jex, S. M., Stacy, B. A., & Murray, M.A. (2000). Impact of context on job stress coping: Work stressors and coworker support as predictors of individual strain and job performance. *Journal of Organizational Behavior, 21*(4), 391-405.

Beehr, T. A., Walsh, J. T., & Taber, T. D. (1976). Relationship of stress to individually and organizationally valued states: Higher order needs as a moderator. *Journal of Applied Psychology*, *61*(1), 41-47.

Brillhart, P. E. (2004). Technostress in the workplace: Managing stress in the electronic workplace. *Journal of American Academy of Business, 5*(1/2), 302-207.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multi trait multi method matrix. *Psychological Bulletin, 56*(2), 81-105.

Carlson, D. S. (1999). Personality and role variables as predictors of three forms of work–family conflict. *Journal of Vocational Behavior*, *55*, 236-253.

Carlson, D. S., & Perrewé, P. L. (1999). The role of social support in the stressor-strain relationship: An examination of work-family conflict. *Journal of Organizational Behavior*, *25*(4), 513-540.

Carver, C. S., & Scheier, M. F. (1990). Origins and functions of positive and negative affect: A control-process view. *Psychological Review*, *97*, 19-35.

Carver, C. S., Scheier, M. F., & Weintraub, J. K. (1989). Assessing coping strategies: A theoretically based approach. *Journal of Personality and Social Psychology*, *56*(2), 267-283.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (ed.), *Modern Methods for Business Research* (pp. 295-336). Mahwah, NJ: Lawrence Erlbaum Associates.

Chun, M. M. (2000). Contextual cueing of visual attention. *Trends in Cognitive Sciences*, *4*(5), 170-178.

Cohen, F. (1984). *Coping*. New York, NY: Wiley.

Comrey, A. L., & Lee, H. B. (1992). *A first course in factor analysis*. Hillsdale, NJ: Erlbaum.

Cooper, C. L. (1998). *Job stress.* Oxford: Oxford University Press.

Cooper, C. L., Dewe, P. J., & O'Driscoll, M. P. (2001). *Organizational stress: A review and critique of theory, research, and applications*. Thousand Oaks, CA: Sage.

Courtney, J. (2007). Privacy and prejudice: An interruption 2.0 manifesto for the AlwaysOn lifestyle: Taking back control of your real time communications in the AlwaysOn world. *Skype Journal.*

Damrad-Frye, R., & Laird, J. D. (1989). The experience of boredom: The role of self-perception of attention. *Journal of Personality and Social Psychology, 57*(2), 315-320.

Daniels, K. (1994). Occupational stress, social support, job control, and psychological well-being. *Human Relations, 47*(12), 1523-1544.

de Jonge, J., Bosma, H., Peter, R., & Siegrist, J. (2000). Job strain, effort-reward imbalance and employee well-being: A large-scale cross-sectional study. *Social Science & Medicine, 50*, 1317-1327.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*(3), 355-391.

Dollard, M. F., Winefield, H. R., Winefield, A. H., & de Jonge, J. (2000). Psychosocial job strain and productivity in human service workers: A test of the demand-control-support model. Journal of Occupational and Organizational Psychology, 73(4), 501-510.

Dwyer, D. J., & Ganster, D. C. (1991). The effects of job demands and control on employee attendance and satisfaction. *Journal of Organizational Behavior, 12*(7), 595-608.

Edwards, J. R. (1996). An examination of competing versions of the person-environment fit approach to stress. *Academy of Management Journal*, *39*(2), 292-339.
Fenlason, K. J., & Beehr, T. A. (1994). Social support and occupational stress: Effects of talking to others. *Journal of Organizational Behavior*, *15*(2), 157-175.
Fornell, C. R., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of Marketing Research, 18*(3), 382-388.
French, J., Caplan, R., & van Harrison, R. (1982). *The mechanisms of job stress and strain*. New York, NY: Wiley.
Ganster, D. C., Fusilier, M., & Mayes, B. (1986). Role of social support in the experience of stress at work. *Journal of Applied Psychology, 71*(1), 102-110.
Garde, A. H., & Hansen, A. M. (2005). Long-term stability of salivary cortisol. *Scandinavian Journal of Clinical & Laboratory Investigation*, *65*, 433-436.
Gefen, D., & Straub, D. W. (2004). Consumer trust in B2C e-commerce and the importance of social presence: Experiments in e-products and e-services. *Omega*, *32*(6), 407-424.
Gordis, E. B., Granger, D. A., Susman, E. J., & Trickett, P. K. (2007). Salivary alpha amylase-cortisol asymmetry in maltreated youth. *Hormones and Behavior*, *53*(1), 96-103.
Granger, D. A., Kivlighan, K. T., Fortunato, C. K., Harmon, A. G., Hibel, L. C., Schwartz, E. B., & Whembolua, G. S. (2007). Integration of salivary biomarkers into developmental and behaviorally-oriented research: Problems and solutions for collecting specimens. *Physiology and Behavior*, *92*(4), 583-590.
Hammer, L. B., Kossek, E. E., Zimmerman, K., & Daniels, R. (2007). Clarifying the construct of family-supportive supervisory behaviors (FSSB): A multilevel perspective. In P. L. Perrewe & D. C. Ganster (Eds.), *Exploring the work and non-work interface* (pp. 165-204). Location: Elsevier.
Harmon, A. G., Towe-Goodman, N. R., Fortunato, C. K., & Granger, D. A. (2008). Differences in saliva collection location and disparities in baseline and diurnal rhythms of alpha-amylase: A preliminary note of caution. *Hormones and Behavior*, *54*(5), 592–596.
Jett, Q. R., & George, J. M. (2003). Work interrupted: A closer look at the role of interruptions in organizational life. *Academy of Management Review*, *28*(3), 494-507.
Jex, S. M., Bliese, P. D., Buzzell, S., & Primeau, J. (2001). The impact of self-efficacy on stressor-strain relations: Coping style as an explanatory mechanism. *Journal of Applied Psychology*, *86*(3), 401-409.
Kahn, R. L. (1964). Organizational stress: Studies in role conflict and ambiguity. New York, NY: Wiley.
Karasek, R., Russell, R. S., & Theorell, T. (1982). Physiology of stress and regeneration in job related cardiovascular illness. *Journal of Human Stress*, *8*, 29-42.
Karasek, R. A. J. (1979). Job demands, job decision latitude, and mental strain: Implications for job Redesign. *Administrative Science Quarterly, 24*(2), 285-308.
Kaufmann, G. M., & Beehr, T. A. (1986). Interactions between job stressors and social support: Some counterintuitive results. *Journal of Applied Psychology*, *71*(3), 522-526.
Kessler, M. (2007). Fridays go from casual to e-mail free. *USA Today.*
Kirmeyer, S. L., & Dougherty, T. W. (1988). Workload, tension, and coping: Moderating effects of supervisor support. *Personnel Psychology, 41*(1), 125-139.
Kushnir, T., & Melamed, S. (1991). Work-load, perceived control and psychological distress in type A/B industrial workers. *Journal of Organizational Behavior*, *12*(2) 1991, pp 155-168.
Landsbergis, P. A. (1988). Occupational stress among health-care workers—a test of the job demands-control model. *Journal of Organizational Behavior*, *9*(3), 217-239.
Lazarus, R. S. (1993). From psychological stress to the emotions: A history of changing outlooks. *Annual Review of Psychology*, *44*, 1-21.
Lazarus, R. S. (1994). *Psychological stress in the workplace*. New York: Taylor and Francis.
Lazarus, R. S., & Cohen, J. B. (1977.). *Environmental stress*. New York: Plenum.
Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer.
Marin, T. J., Martin, T. M., Blackwell, E., Stetler, C., & Miller, G. E. (2007). Differentiating the impact of episodic and chronic stressors on hypothalamic-pituitary-adrenocortical axis regulation in young women. *Health Psychology*, *26*(4), 447-455.
Maslach, C., Schaufeli, W. B., & Leiter, M. P. (2001). Job burnout. *Annual Review of Psychology, 52*, 397-422.
McGrath, J. E. (1976). *Stress and behavior in organizations*. Chicago: Rand McNally College Publishing.

Meyer, D. E., & Kieras, D. E. (1997). A computational theory of executive cognitive processes and multiple-task performance: Part 1. Basic mechanisms. *Psychological Review, 104*(1), 2-65.

Moore, J. E. (2000). One road to turnover: An examination of work exhaustion in technology professionals. *MIS Quarterly*, *24*(1), 141-168.

Mullarkey, S., Jackson, P. R., Wall, T. D., Wilson, J. R., & Grey-Taylor, S. M. (1997). The impact of technology characteristics and job control on worker mental health. *Journal of Organizational Behavior*, *18*(5), 471-489.

Nygaard, A., & Dahlstrom, R. (2002). Role stress and effectiveness in horizontal alliances. *Journal of Marketing, 66*(2), 61-82.

O'Brien, R., & Kaiser, M. (1985). MANOVA method for analyzing repeated measures designs: An extensive primer. *Psychological Bulletin*, *97*(2), 316-333.

Okhuysen, G. A. (2001). Structuring change: Familiarity and formal interventions in problem-solving groups. *Academy of Management Journal, 44*(4), 794-808.

Parasuraman, S., Greenhaus, J. H., & Granrose, C. S. (1992). Role stressors, social support, and well-being among two-career couples. *Journal of Organizational Behavior, 13*(4), 339-356.

Parkes, K. R. (1986). Coping in stressful episodes—the role of individual differences, environmental factors, and situational characteristics. *Journal of Personality and Social Psychology, 51*(6), 1277-1292.

Pearlin, L. I., Lieberman, M. A., Menaghan, E. G., & Mullan, J. T. (1981). The stress process. *Journal of Health and Social Behavior*, *22*, 337-356.

Perlow, L. (2012). *Sleeping with your smartphone: How to break the 24/7 habit and change the way you work*. Cambridge, MA: Harvard Business School Publishing.

Perrewe, P. L. (1987). The moderating effects of activity level and locus of control in the personal control-job stress relationship. *International Journal of Psychology, 22*(2), 179-193.

Perrewe, P. L., & Ganster, D. C. (1989). The impact of job demands and behavioral control on experienced job stress. *Journal of Organizational Behavior, 10*(3), 213-229.

Perrewe, P. L., & Zellars, K. L. (1999). An examination of attributions and emotions in the transactional approach to the organizational stress process. *Journal of Organizational Behavior*, *20*(5), 739-752.

Peterson, M. F., Smith, P. B., Akande, A., Ayestaran, S., Bochner, S., Callan, V., Cho, N. G., Jesuino, J. C., Damorim, M., Francois, P. H., Hofmann, K., Koopman, P. L., Leung, K., Lim, T. K., Mortazavi, S., Munene, J., Radford, M., Ropo, A., Savage, G., Setiadi, B., Sinha, T. N., Sorenson, R., and Viedge, C. (1995). Role conflict, ambiguity, and overload—A 21-nation study. *Academy of Management Journal*, *38*(2), 29-452.

Pierce, J. L., Gardner, D. G., Dunham, R. B., & Cummings, L. L. (1993). Moderation by organization-based self-esteem of role condition employee response relationships. *Academy of Management Journal*, *36*(2), 271-288.

Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., & Tu, Q. (2008). The consequences of technostress for end users in organizations: Conceptual development and empirical validation. *Information Systems Research*, *19*(4), 417-433.

Rizzo, J. R., House, R. J., & Lirtzman, S. I. (1970). Role conflict and ambiguity in complex organizations. *Administrative Science Quarterly*, *15*(2), 150-163.

Rohleder, N., Nater, U. M., Maldonado, E. F., & Kirschbaum, C. (2006). The psychosocial stress-induced increase in salivary alpha-amylase is independent of saliva flow rate. *Psychophysiology*, *43*, 645-652.

Rugulies, R., Bultmann, U., Aust, B., & Burr, H. (2006). Psychosocial work environment and incidence of severe depressive symptoms: Prospective findings from a 5-year follow-up of the Danish Work environment cohort study. *American Journal of Epidemiology*, *163*(10), 877-887.

Sales, S. M. (1969). Organizational role as a risk factor in coronary disease. *Administrative Science Quarterly*, *14*(3) 325-337.

Selye, H. (1956). *The stress of life*. New York: McGraw-Hill.

Selye, H. (1983). The stress concept: Past, present and future. New York, NY: John Wiley.

Selye, H. (1993). *History of the stress concept*. New York: Free Press.

Seshadri, S., & Shapira, Z. (2001). Managerial allocation of time and effort: The implications of interruptions. *Management Science*, *47*(5), 647-662.

Shirom, A. (1982). What is organizational stress? A facet analytic conceptualization. *Journal of Occupational Behaviour*, *3*(1), 21-37.
Smith-Lovin, L., & Brody, C. (1989). Interruptions in group discussions: The effects of gender and group composition. *American Sociological Review*, *54*(3), 424-435.
Smith, T. W. (2006). Personality as risk and resilience in physical health. *Association for Psychological Science*, *15*(5), 227–231.
Speier, C., Valacich, J. S., & Vessey, I. (1997). The effects of task interruption and information presentation on individual decision making. *Proceedings of the XVIII International Conference on Information Systems*, 21-36.
Speier, C., Valacich, J. S., & Vessey, I. (1999). Information overload through interruptions: An empirical examination of decision making. *Decision Sciences, 30*(2), 337-360.
Spira, J. B., & Feintuch, J. B. (2005). *The cost of not paying attention: How interruptions impact knowledge worker productivity*. Basex.
Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. *Management Science*, *32*(11), 1492-1512.
Stein, F., & Cutler, S. K. (2002). Psychosocial occupational therapy: A holistic approach (2nd ed.). Clifton Park, NY: Cengage.
Student. (1908). The probable error of a mean. *Biometrika*, *6*(1), 1-25.
Tarafdar, M., Tu, Q., Ragu-Nathan, B. S., & Ragu-Nathan, T. S. (2007). The impact of technostress of role stress and productivity. *Journal of Management Information Systems*, *24*(1), 301-328.
Tellegen, A., & Atkingon, G. (1974). Openness to absorbing and self-altering experiences ("absorption") a trait related to hypnotic susceptibility. *Journal of Abnormal Psychology*, *83*(3), 268-277.
Thompson, C. (2005). Meet the life hackers. *The New York Times*.
Toffier, B. L. (1981). Occupational role development: The changing determinants of outcomes for the individual. *Administrative Science Quarterly*, *26*(3), 396-418.
Trochim, W. (2004). Research methods: The concise knowledge base. Cincinnati: Atomic Dog Publishing.
Tu, Q., Wang, K., & Shu, Q. (2005). Computer-related technostress in China. *Communications of the ACM*, *48*(4), 77-81.
Van Der Doef, M., & Maes, S. (1999). The job demand-control(-support) model and psychological well-being: A review of 20 years of empirical research. *Work & Stress*, *13*(2), 87-114.
Van Yperen, N., & Hagedoorn, M. (2003). Do high job demands increase intrinsic motivation or fatigue or both? The role of job control and job social support. *Academy of Management Journal*, *46*(3), 339–348.
Wall, T. D., Corbett, J. M., Clegg, C. W., Jackson, P. R., Martin, R., (1990). Advanced manufacturing technology and work design: Towards a theoretical framework. *Journal of Organizational Behavior*, *11*(3), 201-219.
Wall, T. D., Jackson, P. R., Mullarkey, S., & Parker, S. K. (1996). The demands-control model of job strain: A more specific test. *Journal of Occupational and Organizational Psychology*, *69*(2), 153-166.
Wall, T. D., Kemp, N. J., Jackson, P. R., & Clegg, C. W. (1986). Outcomes of autonomous workgroups—A long-term field experiment. *Academy of Management Journal*, *29*(2), 280-304.
Weil, M., & Rosen, L. (1997). *TechnoStress: Coping with technology @WORK @HOME @PLAY* (1st ed.). New York, NY: John Wiley & Sons.
Wright, T. A., & Bonnett, D. G. (2007). Job satisfaction and psychological well-being as nonadditive predictors of workplace turnover. *Journal of Management*, *33*(2), 141-160.
Yuan, C.-S., & Bieber, E. J. (2003). *Textbook of complementary and alternative medicines*. New York: Taylor & Francis.

Appendices

Appendix A: Getting the Task Right

In the episode, the primary task was held constant while we manipulated various characteristics of the ICT-enabled interruptions. We formally defined the primary task after rigorous testing. First, the principal investigator (PI) put together a focus group with 20 undergraduate students. The members were given an assignment to find a task that 1) they found to be engaging and 2) took about 20 minutes. They were instructed to write down all of the steps that they had to take to complete in task (i.e., Is your task a series of mini-tasks or one big task?). In addition, they were encouraged to get together and discuss their ideas.

The rationale for the focus group was to find a task that had no qualitative limitations for students and, therefore, would not be a source of stress for them. Instead, the task needed to be engaging, which differs from a stressful task. An engaging task lets subjects establish a continuous relationship and become absorbed into their workload (Tellegen & Atkingon, 1974). In this sense, while the primary task does serve as demand, it does not serve as a stressor. In our experiments, the ICT-enabled interruptions are the only stressors manipulated for demand, while varying levels of control serves as solutions to those demands; therefore, the task needed to be something that everyone had knowledge to do without needing extra directions.

Based on this rationale, we discarded many ideas because not all 20 students were comfortable with completing them. For example, all business students are required to take a decision-modeling course. Generally, making a simple model takes about 20 minutes and requires little outside resources. However, the sheer instructions of a model could potentially create additional stress on many students outside of the business field. The think tank provided other ideas, too, such as online car buying and real estate investing. However, these tasks require a large amount of Internet resources and are difficult to control in an experimental setting. After pretesting the various tasks, we determined that the most efficient task was a standardized essay, which almost every undergraduate student has the fundamental knowledge to create. Two examples of tasks and instructions (both for controlled and uncontrolled environments) are located below.

The participants were instructed to answer the essay question using a programmed tool. Specifically, they were given 20 minutes to write a short essay, which we adapted from practice essays for the Graduate Management Admission (GMAT) test. While the GMAT typically allocates a maximum of 30 minutes to write and prepare an analogous essay, to ensure the subjects did not finish at different rates and become bored, this time was shortened by 10 minutes. This 20 minute block was also determined after vigorous pretesting with the 23 participants, where we found that 20 minutes was short enough where no one would finish early and get bored, regardless of interruptions. We confirmed this time constraint in the pilot test, which had 19 participants.

Consistent with the GMAT, the instructions requested that the essay must be comprised of greater than 325 words, consist of an introductory paragraph, a body of one or more paragraphs, and a closing paragraph. We also instructed subjects were to use reasons and/or examples from their experiences, observations, Internet usage (depending on their experimental grouping), and/or readings to explain their viewpoint(s). Finally, they were informed that the grading scale would focus on the number of words, the clarity of their writing, and their critical and reasoning skills. This grading scale helped calibrate the level of incentives they received.

Our incentives were designed to set the level of urgency of the task at high and, thereby, induce stress. In the initial pretest, we conducted semi-structured interviews with 19 students to find out what would get them to want to perform well. Our incentives first gave participants a set amount of money, which started with 10 dollars and went down with each unit decrease in performance. Secondly, if students performed well (a 5 or above on our 6 point scale), they would get entered into a raffle for an iPad Touch. Participants who scored a 6 received 2 raffle tickets, while participants who scored a 5 received 1 raffle ticket.

Appendix B: Manipulation Checks and Perceptual Scales

Table B-1. Post-Episode Survey

Below are listed a number of statements that are used to describe the demand you received during the task. Please read each statement carefully and indicate the extent to which each is an accurate or an inaccurate description of your amount of workload during the task.					
Thinking about the interruptions you received while completing the task, answer the following questions.					
	Strongly disagree	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
Quantitative demand: the number of ICT-enabled interruptions					
I received too many interruptions during the task.	1	2	3	4	5
I experienced many distractions during the task.					
The interruptions came frequently.	1	2	3	4	5
Below are listed a number of statements which are used to describe the messages in the interruptions during the task. Please read each statement carefully and indicate the extent to which each is an accurate or an inaccurate description of your experience during the task.					
Thinking about the messages in the interruptions you received while completing the task, answer the following questions.					
Message profile: the type of instrumental support tied to each ICT-enabled interruption (on-task/off-task)					
	Strongly disagree	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
The interruptions helped me accomplish my task.	1	2	3	4	5
The interruptions helped me think about my task.	1	2	3	4	5
Below are listed a number of statements which are used to describe the amount of control you experienced during the task. Please read each statement carefully and indicate the extent to which each is an accurate or an inaccurate description of your experience during the task					
Timing control: whether the individual can decide when to view messages, rather than responding to intruding ICTs					
	Very little	**Little**	**Some**	**Much**	**Very much**
How much control did you have over when to check your messages?	1	2	3	4	5
How much did you set your own pace to read messages?	1	2	3	4	5
How much did you choose when to read your messages?	1	2	3	4	5

Table B-1. Post-Episode Survey (cont.)

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Resource control: enacting the option to relax from the ICT environment and engage in off-task behaviors					
I was provided the time to take an efficient break.	1	2	3	4	5
The break gave me the option to take time off from the computer.	1	2	3	4	5
I had control over if I took a break.	1	2	3	4	5
Thinking about the method you used to complete the essay, answer the following questions.					
Method control: enacting control over the methods used in completing the primary task					
To what extent did you have …	**Not at all**	**To a very little extent**	**To some extent**	**To a great extent**	**To a very great extent**
access to different ways to collect the information required to complete my task.	1	2	3	4	5
control over which sources of information you needed to do your job.	1	2	3	4	5
Below are listed a number of statements which are used to describe your feelings about stress during the task. Please read each statement carefully and indicate the extent to which each is an accurate or an inaccurate description of your amount of workload during the task.					
Thinking about how you felt during the task, answer the following questions.					
	Strongly disagree	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
Perceptual overload: perceiving too many ICT-enabled interruptions in the given time period					
The interruptions made me feel rushed.	1	2	3	4	5
I felt busy due to interruptions.	1	2	3	4	5
The interruptions increased the pressure I felt to get done on time.		1	2	3	4
Perceptual conflict: perceiving an incompatibility in the demand requirements, where the content of the message conflicts with the task					
I felt tension because interruptions were not relevant to completing the task.	1	2	3	4	5
I felt conflicted because many interruptions did not help me accomplish the task.	1	2	3	4	5
I felt stress because I received interruptions that clashed with my task.	1	2	3	4	5
Strain: the psychological and physiological responses of individuals to ICT-enabled demands					
Thinking about how you felt as a result of the task, answer the following questions					
I was drained mentally.	1	2	3	4	5
I suffered from fatigue.	1	2	3	4	5
I felt tired.	1	2	3	4	5
I was strained.	1	2	3	4	5
I felt burned out.	1	2	3	4	5

Appendix C. Getting the Messages Right

In order to test the messages, we executed one focus group, two pretests, and one pilot. We include a sample list of off-task and on-task interruptions in Tables C-1 and C-2.

Stage 1. The focus group

Stage 1 used a focus group. This group was formed of 20 people that came together to discuss criteria for messages that would be applicable to their particular sample group. For off-task messages, they pulled real emails about the university, their clubs, or their activities and stripped the messages of personal information. These messages needed to be 1) off-task, 2) approximately three to four lines of text, 3) not have any pictures or sound, 4) not have any hyperlinks, and 5) not be higher than PG rated.

Converting the real emails to usable messages took five iterations with the focus group to perfect (using that same team of 20).

This iterative process also occurred with the on-task messages. However, on-task messages were created by the authors before going through the iterative process with the focus group. The authors were better suited to create the messages because they needed to aid in the completion of the task (i.e., writing an essay).

Stage 2. Pretest 1

After this revision period, we administered the first pretest using 23 participants. The pretest was exploratory and we used it to calibrate the measures of our variables and the manipulations of our messages. The step-through with the allowed participants to talk aloud and provide detailed feedback as necessary.

The moderator of the pretest handled the participants one at a time. We instructed the moderator to document any verbal/non-verbal behavior (i.e., laughs, cries, grunts) that arose from reading a message. After these messages were flagged, the authors came together and decided which messages needed to be updated.

Stage 3. Pretest 2

After we were satisfied with the first revision of messages, we administered another pretest with 35 new students through scenario analysis. These participants received a packet with a description of the experiment, a screenshot of the programmed tool, and a listing of all messages. They were instructed to circle any messages that seemed ambiguous or did not help solve the task (for on-task messages) and write notes beside it to explain why they circled what they did.

Stage 4. Pilot Test

After these exploratory pretests, we then moved to a more-formal pilot (using full protocol) using 19 participants. We instructed participants were to speak aloud while they executed the task. Here, we also reexamined any messages that the participants indicated during the test.

During the pilot, we collected and analyzed both cortisol and alpha-amylase measures. Both cortisol and alpha-amylase are obtained through a procedure in which saliva is collected from participants. This saliva was stored and then shipped to a lab in PA in order to obtain results. Cortisol is the less reliable measure and was ultimately dropped from the final analysis.

Table C-1. Some Off-Task Interruptions	
Message 1	“I just got off the phone with John and he said the leads are coming in like crazy. Thanks! He's still a little frustrated with Richie but hopes he will do better. John said it's either that or go back to Subway making subs. We put a compensation package together for you that will hopefully make you happy.”
Message 2	“I want you to find any article about CIOs online and tell me what you think about it.”
Message 3	“The information transmitted in the last email is intended only for the person or entity to which it is addressed and may contain confidential and/or privileged material. Any review, retransmission, dissemination or other use of, or taking of any action in reliance upon, this information by persons or entities other than the intended recipient is prohibited. If you received this in error, please contact the sender and delete the material from any computer.”
Message 4	“The completed outline is on the Grove. Please review it and let me know what needs to be changed. I'll print a few copies out, and send the class an electronic version.”
Message 5	“That new movie coming out this fall has already released a trailer on their website. You should check it out. it’s crazy.”
Message 6	“Thank you for your Internet inquiry. Your order is estimated to complete by 4/10/08. Please let us know if you have any other questions. Thank you for choosing Herff Jones for your graduation needs.”
Message 7	“Thank you for your interest in graduate studies at USC. If you have additional questions, please contact me or the appropriate departmental representative for answers to discipline-specific questions. We appreciate your interest in XXX and extend our most sincere best wishes for success in your academic, professional, and personal endeavors.”
Message 8	”Please read the article on operations controls on blackboard and then write a summary paragraph discussing how it pertains to the constructs learned in class today. Highlight questions you may have and be ready for a class wide discussion next week. See you in class.”
Message 9	“Looking for last minute shopping deals? Find them fast with Yahoo! Search.”
Message 10	“It's that time of year again! The XXX Student Advisory Board (XXX) is accepting applications for new members for 2008. XXX is an organization that coordinates the ticket distributions for football and basketball, the XXX Rewards Program, and other various Collegiate Club events throughout the year. If you are interested in becoming an integral part of the XXX Collegiate Club, be sure to fill out an XXX application.”

Note 1: We removed data that pinpointed the college where the study was done was removed and replaced it with XXX.
Note 2: We developed a total of 50 messages for this condition.

Table C-2. Sample On-Task Messages	
Message 1	"Welcome to the company! You should have already been given an assignment to complete an essay. This topic is very important to our company. When you have a blank sheet of paper, sometimes the most difficult thing to do is write the first sentence."
Message 2	"Relax. Take your time and properly plan your argument."
Message 3	"Be particularly concerned with structure. Clearly divide your essay into the introductory paragraph, two to three content paragraphs and a conclusion. Take time out before you start writing to set up an organizational structure."
Message 4	"You are graded by Ph.D's so be a conformist. The graders do not appreciate individuality, humor, or poetic inspiration; they are not known for their sense of humor. They will be comparing the style and structure of your essay to that of other high-scoring essays."
Message 5	"Did you clearly state your critique in the essay? I believe that is key to do when writing an assessment essay."
Message 6	"The best way to fail an essay is to write off the topic—and you'd be surprised by how many people do! Don't touch the keyboard until you've asked yourself the same questions journalists do: What's the issue?"
Message 7	"In order to increase your chances of a good score—you need to write as much as you possibly can."
Message 8	"Pay particular attention to your vocabulary usage. Graders can get easily distracted by poor choices of words."
Message 9	"Be clear on your ideas—but make sure they answer the question. If you have an innovative idea, include it only if it helps your case."
Message 10	"Be sure to proofread your essay. Editing always helps streamline organization and reasoning."
Note: We developed a total of 50 messages for this condition.	

Appendix D: Screenshot Examples

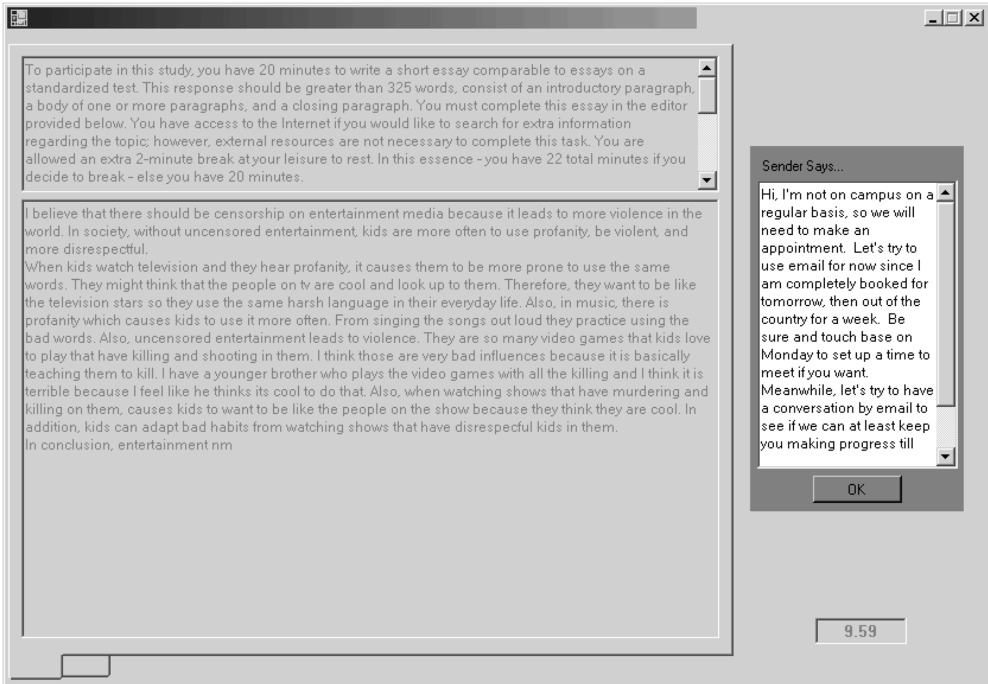


Figure D-1. Off-Task (No Timing Control) Interruption

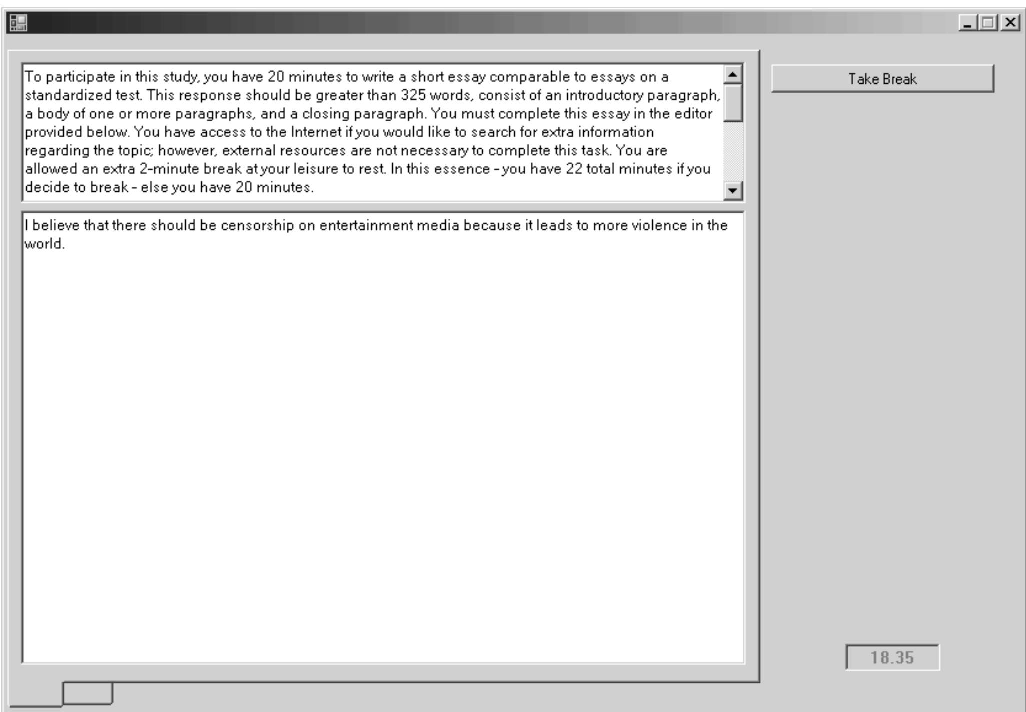
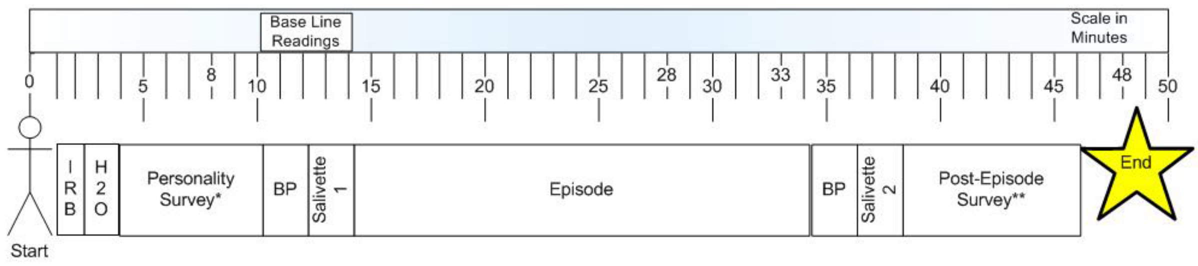


Figure D-2. Example of Break Button

Appendix E: Experimental Flow Chart



* Survey includes items for Internet usage, demographic variables, and stress hormone controls.

** Survey includes manipulation checks for quantitative demand, demand variability, message profile, timing control, method control, and resource control. It also includes items for overload, ambiguity, conflict, strain, and episodic control variable PANAS.

Figure E-1. Experimental Flow Chart

Even though we tested the research model using two separate laboratory experiments, we took each participant through the same process. First, prior to being allowed to begin the experiment, we informed the participants of their rights, and they agreed to conducting the study by signing the approved IRB letter. It is very critical when dealing with stress measures, particularly salivary measures, to have a steady baseline resting rate prior to starting the experiment (Rohleder et al., 2006). We obtained this rate in three ways. First, hormone readings in the morning are generally less stable than those done in the afternoon (Dickerson & Kemeny, 2004); therefore, we conducted all experiments after 11:00 am, when hormones are relatively stable. Second, since we used salivary measures, the participants needed to wash their mouth out with water 10 minutes prior to collection. This prevents contaminants from entering the salivette. Finally, before taking the initial readings, we placed participants in a calm environment in which distractions, such as noise, were limited and the room temperature was appropriate. While keeping the calmness of the environment steady, instead of providing complete downtime when participants' minds could wander, we kept them busy by administering a survey for dispositional and demographic control variables, including Internet usage, gender, and age.

After the 10 minutes had passed, the PI took the first set of readings. To administer the test, participants opened a tube and dropped a cotton-roll-like substance (salivette) into their mouth. We instructed participants to put the tube up to their mouth, tilt their head back slightly, and drop in the cotton roll, while avoiding using their hands or actually touching the cotton roll. They were instructed to swish the roll around in their mouth while refraining from chewing or putting it against their cheek. After two minutes, they took the cotton ball out by putting the empty tube up to their mouth and rolling it out with their tongue. Then, they closed the tube and passed it to the PI who put the tube in a zipper-top bag.

We froze samples immediately after each participant had completed the experiment at -20 degrees Celsius. While -80 degrees Celsius is best for retaining samples for longer than one year, -20 degrees Celsius ensures the short-term stability of samples (Garde & Hansen, 2005). Once all of the samples had been collected and frozen, we packed our samples in dry ice and shipped them through Federal Express (a hazardous materials/HAZMAT-certified shipping company) to the Salimetrics assay company to parse out the salivary hormones (http://www.salimetrics.com). The PI was also HAZMAT-certified prior to collecting and shipping samples. Because certification is required to handle saliva, she was always present to take on that role formally. Samples were labeled according to specific regulations.

The alpha-amylase hormone was extracted from the salivette at the laboratory once the samples were frozen and shipped. After the baseline readings were taken, the participants were given a single sheet of instructions for the episode, which they promptly began after it was clear that they understood the task. Participants were given 20 minutes to complete the task. After the episode was complete, it took five minutes for alpha-amylase to peek post stressor. Therefore, we administered the second salivette after waiting five minutes. This was directly followed with the second survey for the perceptual demands, control, outcomes, and episodic control variables (i.e., PANAS). We concluded the experiment by debriefing the participants and answering any questions they had.

Appendix F: Control Variables

Episodic Control Variables

Table F-1. Episodic Control Variable Survey

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the task. Use the following scale to record your answers.

1	2	3	4	5	
Very slightly or not at All	A Little	Moderately	Quite a bit	Extremely	PANAS

________ distressed ________ excited ________ upset ________ irritable ________ jittery ________ strong ________ guilty ________ scared ________ hostile ________ nervous	________ alert ________ ashamed ________ inspired ________ determined ________ attentive ________ active ________ afraid ________ enthusiastic ________ proud ________ interested	

How many messages do you think you received—estimated number? 0-10 11-20 21-40 41-60 >60

Personal Characteristics Control Variables

Table F-2. Personality Survey

How many years have you used the Internet?	< 6 mo	>6 mon to < 2 yrs	<2 yrs to < 4 yrs	> 4yrs to < 8	> 8 yrs	Internet usage
	Very little	Little	Some	Much	Very much	
How often do you use the Web to search for information?	1	2	3	4	5	
Below are listed a number of statements used to describe how you view the world.						
Gender:	Male	Female				
Age	______					
Ethnicity	Caucasian/ non-Hispanic	Hispanic	Asian	African American	Other	
Class status	Freshman	Sophomore	Junior	Senior		
Have you had alcohol in the last 24 hours?	No	1 drink	2 drinks	3 drinks or greater		Stress hormone controls
Have you had caffeine in the last 2 hours?	No	Very Little	Some	A lot		
Have you had any dairy products or high fructose foods 20 minutes prior to the study?	No	Yes				
Have you eaten a major meal 60 minutes prior to the study?	No	Yes				

Appendix G: Informed Consent Letter

Consent Form for Participation in a Research Study
XXXX
The Impact of Information Technology-Enabled Stressors in the Workplace

Description of the research and your participation
As a researcher at XXXX, you are invited to participate in this study, designed to measure stress in the workplace. You will be recruited along with approximately 200 other undergraduate students. Your participation and responses will contribute to a comprehensive understanding of employee needs and concerns regarding these processes and supportive activities.

The main goal of this experiment is to examine technological interruptions in IT environments, and provide solutions to this reoccurring problem. In doing so, we examine three broad constructs: demands, technology-enabled controls, and strain. You will be asked to perform a performance task on the computer. During your completion of the task, you will receive a series of interruptions. They will come electronically through instant messenger or email.

The experiment is designed to evaluate performance and stress responses regarding these tasks. To do this, this experiment uses non-invasive tools that capture various indicators of strain at frequent time periods. The tools to be used are salivettes and blood pressure cuffs. Salivettes are a standardized method for capturing salivary stress measures. Blood pressure cuffs are used to examine both blood pressure and pulse rate. Finally, the experiment follows up each episode with a quick survey.

Risks and discomforts
Because our techniques used to measure stress are non-invasive, you will be exposed to minimal risk. However, since the study is designed to examine stress affects, consequently you may feel discomfort from a temporary increase in stress levels. This discomfort is designed to be no more than you would receive in an everyday worklife environment. Results from this empirical study will contribute to a greater understanding of stress and technology in the workplace.

Protection of confidentiality
Your responses will remain confidential. Your name is for the sole purpose of verifying your attendance at XXXX and to ensure you receive up to $10 incentive for your efforts and are included in the raffle for the iPod touch. We will do everything we can to protect your privacy and your identity will not be revealed in any publication that might result from this study.

In rare cases, a research study will be evaluated by an oversight agency, such as the XXXX Institutional Review Board or the Federal Office for Human Research Protections, that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

Voluntary participation
Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. Refusal to participate or withdrawal from participation will not involve any penalty or loss of benefits to which you are otherwise entitled.

Early Termination
We desire not to allow persons to participate who have known heart conditions or diagnosed elevated stress levels. Additionally, if these findings become apparent during your participation, the investigator can terminate the participation without your consent. The procedure for an orderly termination will involve the investigator stopping the experiment and asking you how you feel. If issues are confirmed, the investigator will inform you that your participation is finished and the reasonings behind early termination. Early termination will not involve any penalty or loss of benefits to which you are otherwise entitled.

Contact information

The researchers, XXXX, can be reached at XXXX. You may contact the Institutional Review Board at XXXX if you have any questions regarding your rights as a participant. The duration of the experiment should take approximately 50 minutes and relates to how different technology characteristics can either influence or mitigate stress in the workplace. Upon completion of this study, you will receive an incentive up to $10. The raffle for the iPod Touch will take place after all 200 subjects have completed the experiment.

Consent

Signing this form will imply that you have read and understood the foregoing descriptions of this research project. You are entitled to ask for and receive a satisfactory explanation of any language that you don't fully understand. I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's signature: Date:

Appendix H: Exploratory Factor Analysis

Table H-1. Exploratory Factor Analysis

Item	Perceptual stress	Strain	Resource control	Timing control	Quantitative demand	Method control	Message profile
C3	.799						
C2	.751						
C1	.750						
O1	.755						
O3	.723						
O2	.699						
S2	.141	.880					
S5	.279	.857					
S3	.133	.793					
S1	.337	.769					
S4	.363	.628					
RC2	-.050	.001	.888				
RC3	-.209	-.061	.851				
RC1	-.003	-.007	.803				
TC2	-.071	-.055	-.077	.856			
TC3	-.133	-.145	-.065	.822			
TC1	-.113	-.021	.027	.738			
QD3	.130	.051	.045	.023	.828		
QD2	.311	.275	-.123	-.187	.631		
QD1	.379	.318	.015	-.091	.538		
MC2	-.047	.022	.339	-.030	-.115	.845	
MC1	.069	.031	.345	-.083	-.034	.845	
MP2	-.167	-.136	-.020	.137	-.034	.036	.868
MP1	-.137	-.104	-.010	.038	-.198	-.026	.851

About the Authors

Pamela S. GALLUCH is an Associate Professor and Director of Internships at Roanoke College. She holds a BBA in Decision Sciences and Information Systems from the University of Kentucky and a MS in Accounting and Computer Information Systems from Middle Tennessee State University and a PhD from Clemson University. Her research examines the influence of information and communication technology characteristics on stress and coping behaviors. She also studies adaptive and maladaptive uses of the Internet. Her papers appear in *MIS Quarterly* and the *Journal of Information Technology Theory and Application*. She has attended the Southern Management Association's doctoral consortium, the Americas Conference in Information Systems' doctoral consortium, and the ICIS junior faculty consortium. She is also the winner of the Distinguished Alumni Achievement Fellowship for postdoctoral research.

Varun GROVER is the William S. Lee (Duke Energy) Distinguished Professor of Information Systems at Clemson University. He has published extensively in the information systems field, with over 200 publications in major refereed journals. Nine recent articles have ranked him among the top four researchers based on number of publications in the top Information Systems journals, as well as citation impact (h-index). He is Senior Editor for *MISQ Executive*, and Senior Editor (Emeritus) for *MIS Quarterly*, the *Journal of the AIS,* and *Database*. He is currently working in the areas of IT value, system politics and process transformation and recently released his third book (with M. Lynne Markus) on process change. He is recipient of numerous awards from USC, Clemson, AIS, DSI, Anbar, PriceWaterhouse, and so on for his research and teaching and is a Fellow of the Association for Information Systems.

Jason Bennett THATCHER is a Professor of Information Systems at Clemson University. He also directs the Social Analytics Institute, an interdisciplinary center focused on understanding the implications of analytics for individual, organizational, and social issues. His research examines the influence of individual beliefs and characteristics on information technology use. He also studies strategic and human resource management issues related to the application of information technologies in organizations. His work appears in *MIS Quarterly*, *Journal of Applied Psychology*, and other outlets. His work has been supported by the National Science Foundation, National Parks Service, Salesforce.com, IBM, and other organizations. Jason lives in Greenville, SC, where he enjoys high-impact fireworks, a rack of ribs, and soaking in hot springs in the Smokey Mountains.